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 : 17th October 2023`

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, initially upright, is to carry out an inclining test.

Present displacement 4854 t. KM 10.52 m

Total weights on board during the experiment:

Ballast	370 t	Kg 3.52 m.	Tank full.	
Bunkers	192 t	Kg 3.85 m.	Slack tank.	Free surface moment 847 tm.
Fresh Water	76 t	Kg 3.86 m.	Slack tank.	Free surface moment 756 tm
Inclining weights	40 t	Kg 8.89 m.	Two weights, 20 t each.	

At the time of the experiment the boilers are empty. They would usually contain a total of 24 t of water, Kg 4.12 m, with a free surface moment of 142 tm.

Both lifeboats, each weighting 12 t are still ashore and will be fitted on the vessel at a Kg of 19.76 m at a later date.

The plumbline has an effective vertical length of 7.25 m. The inclining weights are shifted transversely 8.20 m on each occasion and the mean horizontal deflection of the plumbline is 65 cm.

Calculate the vessel's Lightship KG.

(30 marks)

2) Answer the following with the aid of diagrams/GZ curves when necessary;
   a) Explain why a vessel carrying timber on deck may be allowed a smaller GM than is usual for a cargo vessel.

(10 marks)

   b) Explain how an increase in the beam of a vessel can improve a vessel's stability and why such improvement is more pronounced at smaller angles of heel.

(10 marks)

   c) Explain why a vessel carrying grain in bulk is required to has higher GM than is usual for a cargo vessel.

(10 marks)

3) A container vessel's particulars are as follows:

Displacement 14 000 t KG 7.75 m Draught 7.200 m

Lateral windage area 5800 m^2. Centroid of the windage area 10.20 m above the waterline.

(a) Construct a righting lever curve up to 60 degrees heel using the KN Tables provided;

(20 marks)

(b) Using the above curve, determine EACH of the following:
   i) Assuming, $L_{W1} = PZA / (1000 \times g \times \Delta)$, the angle of heel due to a steady lateral wind pressure of 504 Pa;
   ii) Assuming, $L_{W2} = 1.5 \times L_{W1}$, the angle of heel if the wind pressure increases by 50 % than above due to gusting.

(05 marks each)

4) A box shaped vessel floating upright on an even keel in salt water has the following particulars:
   - Length BP : 150.00 m
   - Breadth: 28.00 m
   - Even keel draught: 8.60 m
   - KG: 9.20 m

The vessel has two longitudinal bulkheads each 9.00 m from the side of the vessel. Calculate the angle of heel if an amidship side compartment having a length of 24.00m is bilged.

(30 marks)

5) a) With the aid of a diagram, derive the following formula;

Tan (list) = listing moment / (displacement x GM)

(05 marks)

A vessel is floating upright with the following particulars;
Displacement = 10180 t KM = 9.6 m

A locomotive weighing 120 t is to be loaded using the vessels heavy lift from a position 18.0 m to port of the vessel's centre line. The derrick head is 21.0 m above the keel.

b) Calculate the maximum allowable KG prior to loading in order to limit the list to a maximum of 6^0 during the loading operation.

(15 marks)

c) Using the KG calculated above, determine the final angle of list if the locomotive is stowed in a position, Kg 2.50 m, 4.00 m to port of the vessels centre line.

(10 marks)

6) A vessel is floating in SW at draught Fwd 3.80 m, aft 6.40 m. A total of 2400 tonne 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)

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

Answers

Answer 1

GM = d x w x Pendulum length / (W x Deflection) = 8.2 x 20 x 7.25 / (4854 x 0.65)

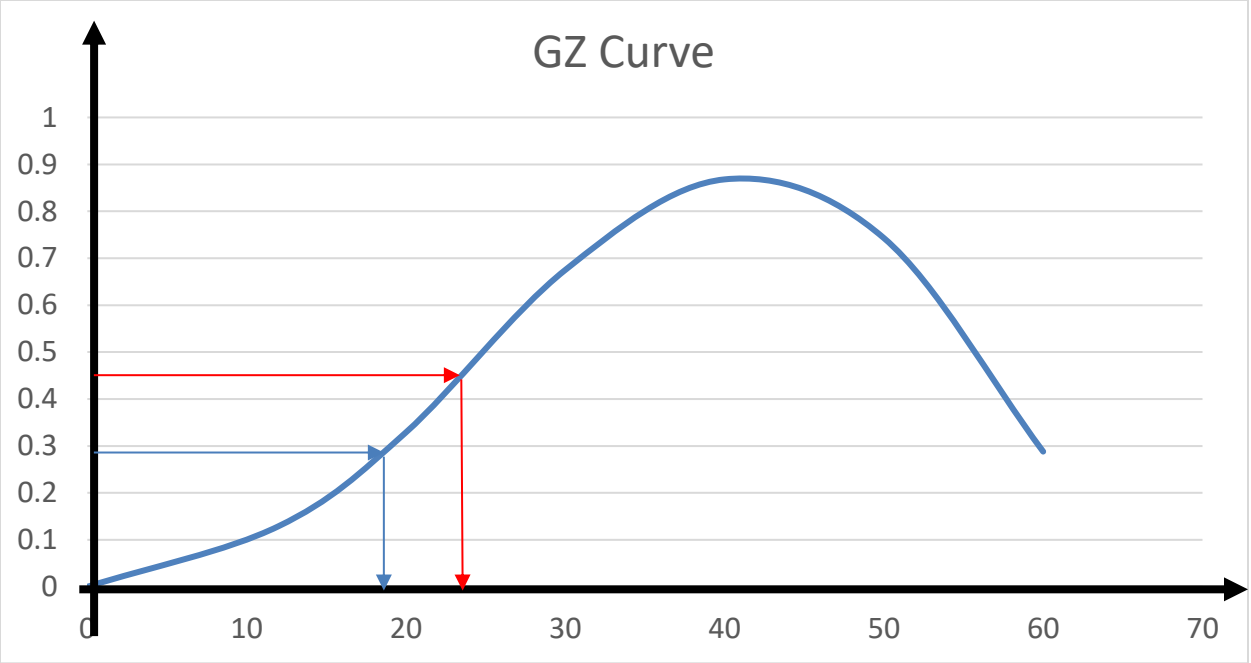
Effective GM = 0.38 m

Effective KG = 10.52 – 0.38 = 10.14 m

Remarks			KG	Moments	
	Load	Discharge		Load	Discharge
Ship	4854		10.14	49219.56	
Ballast		370	3.52		1302.4
Bunkers		192	3.85		739.2
FSM					847
Fresh water		76	3.86		293.36
FSM					756
Inclining weights		40	8.89		355.6
Life boats	12 x 2		19.76	474.24	
Boiler water	24		4.12	98.88	
FSC				142	
Total	**4902**	**678**		**49934.68**	**4293.56**
	- 678			- 4293.56	
Resultant	**4224**			**45641.12**	

Light ship KG = 45641.12 / 4224 = 10.81 m

Answer 3



Wind heeling lever for 504 Pa (lw_1) = P x A x Z / (1000 x W x g)

= 504 x 5800 x 13.8 / (1000 x 14000 x 9.81)

= 0.294 m

Wind heeling lever for 50% of higher wind (lw_2) = 1.5 x lw_1 = 1.5 x 0.294 = 0.441 m

Angle of heel for (lw_1) = 19 degrees

Angle of heel for (lw_2) = 23 degrees

Answer 4

Volume of buoyancy lost = Volume of Buoyancy gained

24 x 9 x 8.6 = [(150 x 28) – (24 x 9)] x S

S = 1857.6 / 3984 = 0.466 m

Bilged draught= 8.6 + 0.466 = 9.066 m

Moments of areas about the axis XX

	Area	Distance from XX	Moments
Total area	150 x 28	14.0	58800
Bilged area	24 x 9	4.5	- 972
Resultant	3984		57828

New location of LCF = 14.515 m

Distance BB_H = 14.515 – 14.0 = 0.515 m

Calculate moment of inertia about new LCF

$I_{LL} = I_{xx} - Ad^2$

$= (150 \times 28^3 / 3) - 24 \times 9^2 / 3) - [(150 \times 28) - (24 \times 9) \times 14.515^2]$

$= (1097600 - 5832) - 839369.936 = 252398.064\ m^4$

Calculate bilged BM, KB, KM and GM

BM = 252398.064 / (150 x 28 x 8.6) = 6.988 m

KB = 9.066 / 2 = 4.533 m

KM = 4.533 + 0.593 = 11.521 m

GM = 11.521 – 9.2 = 2.321 m

Calculate list

Tan θ = 0.515 / 2.321

List = $\underline{\underline{12.5^0}}$

Answer 5(a)

$$\tan\theta = \frac{GG_1}{GM}$$

Where,
GM - final fluid GM

But, since, $GG_1 = w \times d / W$

$$\tan\theta = \frac{d \times w}{W \times GM}$$

Where,

d x w - final listing moment

Therefore,

Tan (list) = listing moment / (displacement x GM)

Question – 5(b)

If the initial KG is 'Q', KG after taking the weight by the derrick is KG_1 and the GM after taking the weight by the derrick is GM_1;

Vertical GG_1 = w x d / W

= 120 (21 – Q) / 10300

KG_1 = Q + 120 (21 – Q) / 10300

= (10180 x Q + 2520) / 10300

KM = 9.6 m

GM_1 = 9.6 – (10180 x Q + 2520) / 10300

= 96360 – 10180 x Q / 10300

Horizontal GG_1 = w x d / W

= 120 x 18 / 10300 = 0.21 m

But, Tan (list) = horizontal GG_1 / (displacement x GM_1)

Tan 6 = 0.21 / 96360 – 10180 x Q

Q = 7.44 m

Maximum allowable KG = 7.44 m

Question – 5(c)

Vertical GG_1 after loading = 120 x (7.44 – 2.5) / 10300

= 0.058 m

Initial GM = 9.6 – 7.44 = 2.16 m

Therefore GM after loading = 2.16 + 0.058 = 2.218 m

Tan list = w x d / (Displacement x GM)

= 120 x 4 (10300 x 2.218)

List = 1.2^0 (Port)

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