# 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 : 07th April 2022

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) Define the term bilging and the list the effects on a vessel as a result of bilging.

(05 marks)

b) A vessel 180 m long & 20 m wide is boxed shaped and afloat in salt water at an even keel draft of 7.40 m. A double bottom tank at the midship, starboard side is rectangular 10 m long, 10 m wide, 1.0 m deep and empty. Calculate the list if this tank is now bilged, given that KG = 7.6 m and FSM = 900 tm.

(25 marks)

2) a) A ship has to cross a bar where the maximum depth of water is 9.5 m. The present draughts are;

Fwd 7.55 m Aft 9.00 m

What is the minimum amount of ballast to transfer forward through a distance of 62 m in order to cross the bar with an under keel clearance of 0.80 m. Hydrostatic particulars are as follows:

LBP = 136 m MCTC 248
LCF = 65.6 m forward of aft perpendicular

(20 marks)

b) Calculate the final draughts

(10 marks)

3) Prior to entering dry dock, a vessel (LBP 167.87) has draughts fwd 4.86 m and aft 5.24 m and an effective KG of 9.16 m. With the aid of attached hydrostatic particulars, calculate:

a) the GM at the critical instant;

(25 marks)

b) the draughts at the same time

(05 marks)

4) Answer the following questions with regards to parametric rolling:
   a) What is parametric rolling?

(05 marks)

   b) Why does the parametric rolling occur on container ships very frequently?

(05 marks)

   c) With the aid of GZ curves explain the impacts of parametric rolling on ship's stability.

(20 marks)

5) A box shaped vessel has length 80 m and breadth 10 m and floating in the light condition at a draught of 3.0 m in water RD 1.010. It is divided into four holds of equal length. Cargo is loaded as follows:

| | |
|---|---|
| No. 1 | 120 t |
| No. 2 | 120 t |
| No. 3 | empty |
| No. 4 | 160 t |

Construct the curves of shear force and bending moment, calculating the maximum values and stating the positions where they occur.

(30 marks)

6) A vessel has a summer displacement of 26 000 t which corresponds to an even keel draught of 11.0 m in salt water.

In a partly loaded condition the vessel has the following particulars:

| | | | |
|---|---|---|---|
| Length B.P. | 200.0 m | LCF | 90.0 m (foap) |
| Displacement | 23 000 t | MCTC | 215 |
| Drafts (in SW) fwd | 8.60 m | aft | 9.50 m |

The vessel is to complete loading at the summer displacement, with a trim of 0.50 m by the stern.

The remaining cargo is to be loaded into two holds:
No. 1 Hold (Lcg 170.0 m, foap)
No. 7 Hold (Lcg 40.0 m, foap)

Calculate:
   a) The quantities to be loaded in each of the holds

(20 marks)

   b) The final draughts in salt water

(10 marks)

## Hydrostatic particulars

| Draught m | Displ. t SW RD 1.025 | TPC t SW RD 1.025 | MCTC t-m SW RD 1.025 | LCB m FOAP | LCF m FOAP | KB m | KML m Above Base | KMT m Above Base |
|---|---|---|---|---|---|---|---|---|
| 3.00 | 8770 | 31.35 | 302 | 87.34 | 87.31 | 1.55 | 586 | 14.94 |
| 3.10 | 9090 | 31.39 | 303 | 87.34 | 87.26 | 1.60 | 566 | 14.58 |
| 3.20 | 9400 | 31.43 | 304 | 37.33 | 87.21 | 1.66 | 548 | 14.23 |
| 3.30 | 9720 | 31.48 | 305 | 87.33 | 87.15 | 1.71 | 531 | 13.92 |
| 3.40 | 10030 | 31.52 | 306 | 87.32 | 87.11 | 1.76 | 515 | 13.62 |
| 3.50 | 10350 | 31.55 | 306 | 87.32 | 87.06 | 1.81 | 500 | 13.32 |
| 3.60 | 10660 | 31.58 | 307 | 87.32 | 87.02 | 1.86 | 486 | 13.04 |
| 3.70 | 10980 | 31.60 | 307 | 87.31 | 86.98 | 1.91 | 473 | 12.80 |
| 3.80 | 11290 | 31.62 | 307 | 87.30 | 86.94 | 1.97 | 461 | 12.58 |
| 3.90 | 11610 | 31.65 | 308 | 87.29 | 86.90 | 2.02 | 449 | 12.34 |
| 4.00 | 11930 | 31.68 | 308 | 87.28 | 86.86 | 2.07 | 438 | 12.16 |
| 4.10 | 12240 | 31.71 | 308 | 87.27 | 86.78 | 2.12 | 427 | 11.97 |
| 4.20 | 12560 | 31.74 | 308 | 87.25 | 86.70 | 2.17 | 417 | 11.79 |
| 4.30 | 12880 | 31.76 | 308 | 87.24 | 86.61 | 2.22 | 407 | 11.62 |
| 4.40 | 13200 | 31.78 | 309 | 87.22 | 86.52 | 2.27 | 398 | 11.46 |
| 4.50 | 13520 | 31.81 | 309 | 87.20 | 86.44 | 2.32 | 389 | 11.32 |
| 4.60 | 13840 | 31.84 | 310 | 87.19 | 86.41 | 2.37 | 381 | 11.18 |
| 4.70 | 14160 | 31.87 | 310 | 87.17 | 86.38 | 2.42 | 373 | 11.05 |
| 4.80 | 14480 | 31.90 | 311 | 87.15 | 86.36 | 2.48 | 366 | 10.93 |
| 4.90 | 14800 | 31.93 | 311 | 87.13 | 86.34 | 2.53 | 358 | 10.81 |
| 5.00 | 15120 | 31.96 | 312 | 87.11 | 86.32 | 2.58 | 351 | 10.70 |
| 5.10 | 15440 | 32.00 | 312 | 87.09 | 86.30 | 2.63 | 345 | 10.60 |
| 5.20 | 15760 | 32.04 | 313 | 87.08 | 86.27 | 2.68 | 339 | 10.50 |
| 5.30 | 16080 | 32.07 | 314 | 87.06 | 86.25 | 2.73 | 333 | 10.41 |
| 5.40 | 16400 | 32.10 | 315 | 87.05 | 86.23 | 2.78 | 328 | 10.32 |
| 5.50 | 16720 | 32.14 | 316 | 87.03 | 86.21 | 2.83 | 322 | 10.24 |
| 5.60 | 17040 | 32.18 | 317 | 87.02 | 86.18 | 2.88 | 317 | 10.16 |
| 5.70 | 17370 | 32.22 | 318 | 87.00 | 86.15 | 2.93 | 312 | 10.09 |
| 5.80 | 17690 | 32.26 | 319 | 86.99 | 86.12 | 2.99 | 307 | 10.02 |
| 5.90 | 18020 | 32.30 | 320 | 86.97 | 86.09 | 3.04 | 303 | 9.96 |
| 6.00 | 18340 | 32.34 | 321 | 86.95 | 86.05 | 3.09 | 299 | 9.90 |
| 6.10 | 18660 | 32.38 | 322 | 86.94 | 86.01 | 3.14 | 295 | 9.85 |
| 6.20 | 18990 | 32.42 | 323 | 86.92 | 85.97 | 3.19 | 291 | 9.80 |
| 6.30 | 19310 | 32.46 | 324 | 86.91 | 85.93 | 3.24 | 287 | 9.75 |
| 6.40 | 19640 | 32.51 | 325 | 86.89 | 85.89 | 3.29 | 283 | 9.70 |
| 6.50 | 19960 | 32.56 | 327 | 86.87 | 85.84 | 3.34 | 279 | 9.66 |
| 6.60 | 20290 | 32.61 | 328 | 86.86 | 85.78 | 3.39 | 276 | 9.62 |
| 6.70 | 20610 | 32.66 | 329 | 86.84 | 85.72 | 3.44 | 273 | 9.58 |
| 6.80 | 20940 | 32.71 | 331 | 86.82 | 85.66 | 3.50 | 270 | 9.55 |
| 6.90 | 21270 | 32.76 | 333 | 86.80 | 85.60 | 3.55 | 267 | |

## Answers

**Answer – 1(b)**

S = 10 x 10 x 1 / (180 x 20) = 0.028 m

Bilged draft = 7.428 m

Take moments of volumes about the keel to calculate the bilged KB,

180 x 20 x 7.4 (bilged KB) = 180 x 20 x 7.4 x (7.4 / 2) – 10 x 10 x 1 x (1/2) + 10x10x 1 x (7.414)

Bilged KB = 3.726 m

$BM_T$ = $LB^3$ / (12 x V) = 180 x $20^3$ / (12 x 180 x 20 x 7.4)

= 4.505 m

Bilged $KM_T$ = 4.505 + 3.726 m = 8.231 m

Bilged GM = 8.231 – 7.6 m = 0.631 m

FSC = 900 / (180 x 20 x 7.4 x 1.025)

= 0.033 m

Bilged fluid GM = 0.631 – 0.033 m = 0.598 m

To calculate $BB_1$ take moments of volumes about vertical axis through the initial COB;

$BB_1$ = 10 x 10 x 1 x (5) / (180 x 20 x 7.4)
= 0.019 m
BG = 0.019 m
Tan (list) = BG / $GM_f$ = 0.019 / 0.598

List = $1.8^0$ (STBD side)

**Answer 2(a)**

Water depth available = 9.5 m

Clearance required = 0.80 m

Max. draught allowed = 8.70 m

Deepest draught (aft) = 9.00 m

Reduction required (aft) = 0.30 m = 30 cm

Ta = 30 cm

Ta = COT x LCF(foap) / LBP

30 = COT x 65.6 / 136

COT = 30 x 136 / 65.6 = 62.2 cm

COT = w x d / MCTC

62.2 = w x 62 / 248

w = 62.2 x 248 / 62 = 248.8 t

**Answer 2(b)**

Tf = COT - Ta = 62.2 – 30 = 32.2

| | Fwd | Aft |
|---|---|---|
| Initial | 7.55 | 9.00 |
| Tf / Ta | + 0.322 | - 0.300 |
| Final | 7.872 | 8.700 |

**Answer 3(a)**

AMD = 5.05 m
LCF for AMD = 86.32 + (-0.02 x 0.05 / 0.1) = 86.31 m foap

TMD = Ta – (trim x $LCF_{foap}$ / LBP) = 5.24 – (0.38 x 86.31 / 167.87)
TMD = 5.045 m

For above TMD from tables
Displacement = 15264 t
MCTC = 312
$LCF_{foap}$ = 86.31 m

P = COT x MCTC / $LCF_{foap}$ = 38 x 312 / 86.31 =138 t

Effective displacement = Displacement – P = 15264 – 138 = 15126 t

From tables KM for effective displacement
KM = 10.698 m

Loss of GM

| | | | |
|---|---|---|---|
| Loss of GM | = P x KG / (W – P) | or | P x KM / W |
| | = 138 x 9.16 / (15264 – 138) | or | 138 x 10.698 / 15264 |
| | = 0.084 m | or | 0.097 m |

| | | |
|---|---|---|
| KM at critical instant | 10.698 | 10.698 |
| KG | 9.16 | 9.16 |
| Initial GM | 1.538 | 1.538 |
| Loss of GM | 0.084 | 0.097 |
| GM at critical instant | 1.454 | 1.441 |

**Answer 3(b)**

TMD before entering = 5.045 m
TPC for above TMD = 31.98

Reduction in TMD (cm) = P / TPC = 138 / 31.98 = 4.3 cm
Draught at critical instant = 5.045 – 0.043 = 5.002 m

OR

Effective displacement = 15264 – 138 = 15126 t
Draught for above displacement = 5.002 m

**Answer 5**

Light displacement = 80 x 10 x 3 x 1.010 = 2424 t

Lightship displacement per m run = 2424 / 80 = 30.3 t/m

Total displacement = 2424 + 120 + 120 + 160 = 2824 t
Buoyancy per m run = 2824 / 80 = 35.3 t/m

| | Hold 1 | Hold 2 | Hold 3 | Hold 4 |
|---|---|---|---|---|
| Light ship m run | 30.3 | 30.3 | 30.3 | 30.3 |
| Cargo per m run | 6 | 6 | 0 | 8 |
| Buoyancy m run | 35.3 | 35.3 | 35.3 | 35.3 |
| Load per m run | - 1 | - 1 | + 5 | - 3 |

SF at 10 m intervals:
0, -10 t, -20 t, -30 t, -40 t, +10 t, +60 t, +30 t, 0 t

BM at 10 m intervals:
0, -50 t, -200 t, -450 t, -800 t, -950 t, -600 t, -150 t, 0

Max SF = 40 t at 40 m foap
Max BM = - 960 t at 32 m foap

**Answer 6(a)**

Cargo to load = 26000 – 23000 = 3000 t

Initial trim = 0.9 m stern

Final trim = 0.5 m stern

COT = 0.9 – 0.5 = 0.4 m (head)

Assuming cargo to be loaded in hold number 1 is Y (t), the trimming moment around the COF
= 80 x Y – 50 x (3000 – Y)

= 130 x Y – 150000

COT = trimming moment/MCTC

0.40 x 100 = (130 x Y – 150000) / 215

130Y = 158600

Y = 1220 t

Cargo to load in hold no. 1 = 1220 t

Cargo to load in hold no. 7 = 3000 – 1220 = 1780 t

**Answer 6(b)**

Maximum even keel draught = 11.00 m

COT from this draught = 0.5 m by stern

Ta = 0.5 x 90 / 200 = 0.225 m

Tf = 0.5 – 0.225 = 0.275 m

Therefore draught fwd = 11.00 – 0.275 = 10.725 m

Aft draught = 11.00 + 0.225 = 11.225 m