(12)

CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY
MARINE ENGINEER OFFICER

STCW 78 as amended MANAGEMENT ENGINEER REG. III/2 (UNLIMITED)

040-34 - NAVAL ARCHITECTURE

FRIDAY, 26 MARCH 2021

0915 - 1215 hrs

Materials to be supplied by examination centres

Candidate's examination workbook Graph paper

Examination Paper Inserts

Worksheet Q3 - Hydrostatic Curves

Notes for the guidance of candidates:

1. Examinations administered by SQA on behalf of the Maritime & Coastguard Agency
2. Candidates should note that 96 marks are allocated to this paper. To pass, candidates must achieve 48 marks
3. Non-programmable calculators may be used.
4. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Maritime & Coastguard Agency

SQA

NAVAL ARCHITECTURE

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

1. The end bulkhead of the wing tank of an oil tanker has the following widths at 3.3 m intervals, commencing from the deck are 6.36, 6.36, 5.72, 3.82 and 0.64 m.

   The tank is full of oil of density 810 kg/m^3.

   Calculate EACH of the following:

   (a) the load on the bulkhead; (8)

   (b) the position of the centre of pressure. (8)

2. Table Q2 gives values of righting levers (GZ) relating to a ship of 10500 tonne displacement in a particular load condition:

Angle of heel (degrees)	0	15	30	45	60	75	90
GZ (m)	0	0.47	1.20	1.50	1.34	0.74	- 0.22

Table Q2

   In the above condition the ship has 315 tonne of fuel stored in a double bottom tank which has to be emptied for survey. This oil is transferred to a wing deep tank, through a transverse distance of 5 m and a vertical height of 4 m.

   (a) Draw the amended curve of statical stability, neglecting the effects of free surface. (12)

   (b) Determine EACH of the following from the curve drawn in Q2(a):

   (i) the angle to which the ship will list; (1)

   (ii) the range of stability. (1)

   (c) Calculate the righting moment at an angle of 25°. (2)

3. A ship is loaded to a displacement of 12262 tonne in sea water of density 1025 kg/m^3. In this condition the centre of gravity above the keel (KG) is 6.28 m and the longitudinal position of the centre of gravity (LCG) is 0.66 m forward of midships.

A rectangular tank, forward of midships, of length 15 m, breadth 12 m and depth 5 m is partially filled with 738 tonne of sea water ballast to give a final trim of 0.75 m by the stern and an effective metacentric height of 1.25 m.

Determine for the ballast tank, EACH of the following, using the hydrostatic curves given in Worksheet Q3:

(a) the height of the base above keel; (8)

(b) the position of the forward bulkhead from midships. (8)

4. A box shaped vessel is 100 m long, 20 m wide and floats at a draught of 5 m.

Due to a collision, a full width compartment 25 m long situated at midships, is bilged.

Calculate EACH of the following using the *lost buoyancy* method:

(a) the permeability of the compartment if the final draught in the bilged condition is 5.85 m; (4)

(b) the change in transverse metacentric height due to bilging this compartment. (12)

5. A box shaped barge of length 70 m has a hull mass of 420 tonne which is evenly distributed throughout its length. Bulkheads are located 5 m from the barge ends to form peak tanks which are empty.

The remainder of the barge is divided by two transverse bulkheads to form three holds of equal length. These holds are loaded with a total of 1680 tonne of level stowed bulk cargo, 480 tonne of which is loaded in the centre hold and the remainder is equally distributed in the other two holds.

Using graph paper, draw EACH of the following curves on a base of ship length:

(a) weight and buoyancy curves; (5)

(b) load curve; (3)

(c) shear force curve; (4)

(d) bending moment curve. (4)

6. A single screw ship with a service speed of 15 knots is fitted with a rectangular rudder, 5.5 m deep and 3.5 m wide with the axis of rotation 0.4 m aft of the leading edge. At a rudder angle of 35°, the centre of effort is 32% of the rudder width from the leading edge.

The force on the rudder normal to the plane of the rudder is given by the expression:

$F_n = 577\ A\ v^2 \sin\alpha$ newtons

where:
- A = rudder area (m^2)
- v = ship speed (m/s)
- α = rudder angle (degrees)

The maximum stress in the rudder stock is to be limited to 70 MN/m^2.

Determine EACH of the following:

(a) the minimum diameter of the rudder stock required for ahead running; (9)

(b) the speed of the ship, when running astern, at which the maximum stress level would be reached. (7)

7. A ship 140 m long has a load displacement of 21750 tonne in sea water of density 1025 kg/m^3. To maintain a speed of 16.5 knots in the above condition on trials, a shaft power of 7800 kW is required.

SCF for trial condition	=	1.08
SCF for service condition	=	1.24
Quasi-propulsive coefficient (QPC)	=	0.69
Transmission losses	=	3%
Wetted surface area (m^2)	=	$2.57\sqrt{\Delta L}$

Using the information given above, calculate the shaft power required in service for a geometrically similar ship of 26750 tonne load displacement operating at the corresponding speed. (16)

Note: *The frictional coefficient for the 21750 tonne ship in sea water is 1.415*
The frictional coefficient for the 26750 tonne ship in sea water is 1.413
Speed is in m/s and speed index n = 1.825

8. The following data were obtained during acceptance trials for a ship of 8000 tonne displacement:

ship speed	=	15.5 knots
propeller torque	=	250 kNm
propeller thrust	=	325 kN
propeller speed	=	1.75 revs/s
propeller efficiency	=	66%
effective power	=	2010 kW
apparent slip ratio	=	0.06
transmission losses	=	3%

Calculate EACH of the following:

(a) the pitch of the propeller; (3)

(b) the Taylor wake fraction; (5)

(c) the real slip ratio; (1)

(d) the thrust deduction fraction; (3)

(e) the quasi-propulsive coefficient; (1)

(f) the Admiralty Coefficient based upon shaft power. (3)

9 (a) Explain the meaning of the term *propeller cavitation*. (6)

(b) Describe with reasons, the areas on a propeller blade that are more susceptible to cavitation. (5)

(c) State how *face cavitation* may occur. (2)

(d) Explain why cavitation on a propeller is not steady and the consequence of this. (3)