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, 17 DECEMBER 2021

0915 - 1215 hrs

Materials to be supplied by examination centres

Candidate's examination workbook Graph paper

Examination Paper Inserts

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.

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3. A ship of 125 m length has the following particulars when floating in sea water of density 1025 kg/m^3.

displacement	=	11923 tonne
draught aft	=	7.244 m
draught forward	=	6.844 m
longitudinal metacentric height (GM_L)	=	130 m
longitudinal centre of flotation (LCF)	=	2.5 m aft of midships
tonne per centimetre immersion (TPC)	=	18.5

TWO tanks, EACH containing a substantial quantity of water ballast, are situated with their centres of gravity 50 m aft of midships and 25 m forward of midships respectively.

The vessel is required to enter dock with a draught aft of 7.0 m and a trim of 0.6 m by the stern.

Calculate the mass of ballast to be removed from each tank. (16)

4. A ship of displacement 14000 tonne has a length 130 m, breadth 17 m, and even keel draught of 6.11 m in sea water of density 1025 kg/m^3.

The area of the waterplane is 1600 m^2 and the second moment of area of the waterplane about a transverse axis through midships is 1.25×10^6 m^4 with the LCF at midships.

The ship has a full depth empty rectangular compartment having length 13 m and breadth 11 m.

The centre of the compartment is on the centreline of the ship 30 m forward of midships.

Calculate the end draughts after the compartment is bilged.

Note: For the purposes of calculating the MCT1cm it can be assumed that $GM_L = BM_L$ (16)

5. A rectangular oil barge of light displacement 640 tonne is 80 m long and 12 m wide.

The barge is divided by four transverse bulkheads into five compartments of equal length.

When compartments 2 and 4 contain equal quantities of oil and the other compartments are empty, the barge floats at a draught of 4 m in fresh water of density 1000 kg/m^3.

(a) Draw EACH of the following curves on a base of barge length:

(i) curve of loads; (4)

(ii) curve of shearing forces; (4)

(iii) curve of bending moments. (5)

(b) State the magnitude and position of the maximum bending moment. (3)

6. (a) With the aid of an outline sketch explain EACH of the following:

(i) unbalanced rudder; (2)

(ii) semi-balanced rudder; (2)

(iii) balanced rudder. (2)

(b) State the principal advantage of fitting a balanced rudder. (1)

(c) A ship travelling at full speed has its rudder put hard over to port, where it is held until the ship completes a full turning circle.

Describe, with the aid of a sketch, how the ship will heel from the upright condition *during* the manoeuvre. Illustrate the moments produced by the forces acting on the ship and the rudder. (9)

7. The following values of effective power (naked hull) refer to a ship which is to have a service speed of 16.25 knots.

Speed (knots)	15	15.5	16	16.5	17.0
ep_n (kW)	6320	6890	7820	9220	11000

The following data also apply:

appendage allowance	=	7%
weather allowance	=	14%
quasi propulsive coefficient	=	0.71
transmission losses	=	3%
engine mechanical efficiency	=	86%

Ratio of service indicated power to installed machinery indicated power = 0.9.

Determine EACH of the following:

(a) the indicated power of the engine to be installed; 19107.50 (8)

(b) the speed obtained if all the available power of the engine is used:

(i) when the ship is running on acceptance trial in calm conditions; 16.925 (4)

(ii) when operating under actual service conditions. 16.55 (4)

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8. (a) The residuary resistance of a 1/25 scale model of a ship is 7.68 N when tested at 1.646 m/s in fresh water of density 1000 kg/m^3.

The frictional resistance of the ship at 12 knots in sea water of density 1025 kg/m^3 is 148 kN.

Frictional resistance can be assumed to vary with speed to the power 1.825.

Calculate the effective power (naked) for the ship at the speed *corresponding* to the model test. 3071.35 (8)

(b) The following additional data apply to the ship operating in service at the corresponding speed calculated in Q8(a) with a propeller having a pitch of 4.8 m.

appendage and weather allowance	=	24%
quasi propulsive coefficient (QPC)	=	0.71
propeller speed	=	1.85 revs/s
Taylor wake fraction	=	0.3
propeller thrust	=	650 kN

Calculate EACH of the following:

(i) the torque delivered to the propeller; 461.47 (3)

(ii) the propeller efficiency; 69.81 % (3)

(iii) the real slip ratio. 35.12 (2)

9. An end bulkhead of an upper hopper tank is shown in Fig Q9.

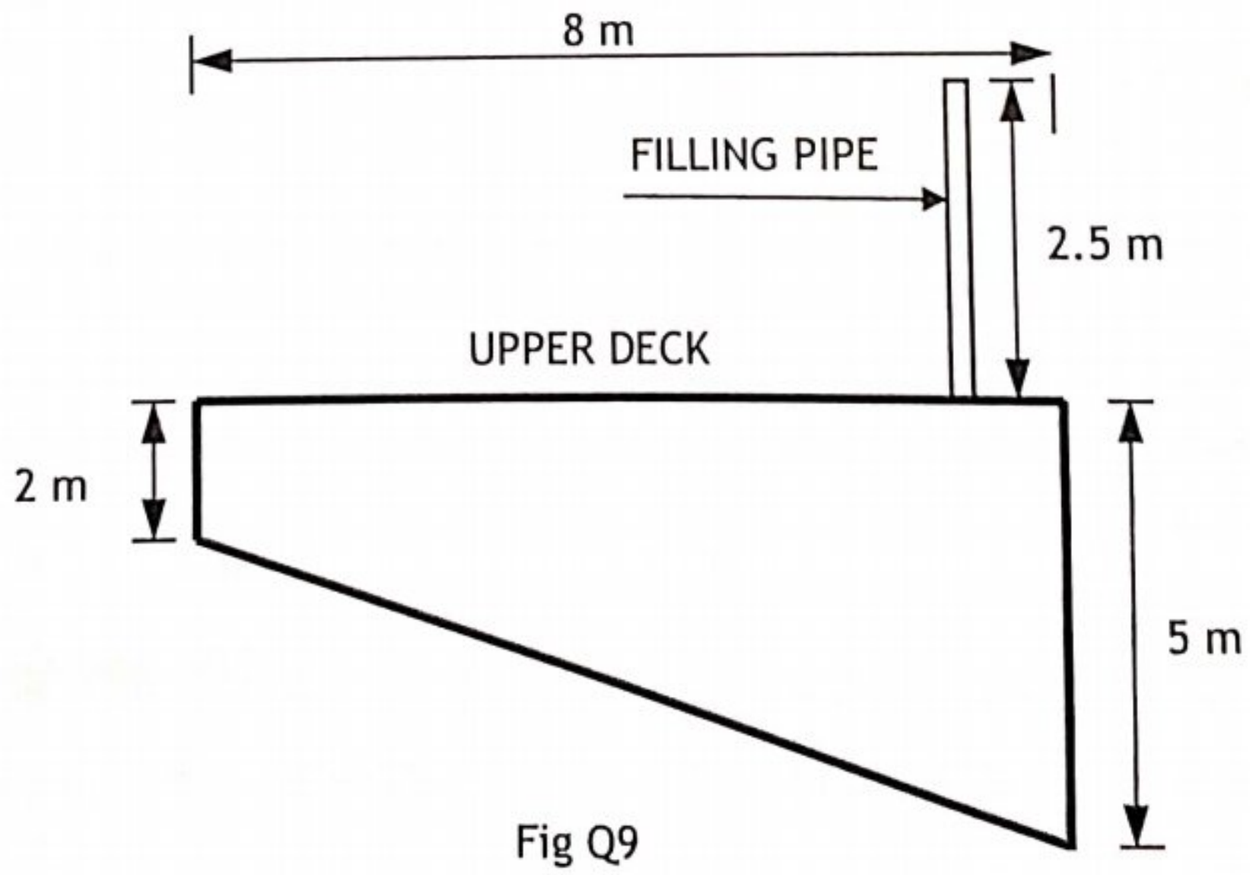

Fig Q9

The tank is tested by filling with fresh water of density 1000 kg/m^3 through a filling pipe to a head of 2.5 m above the upper deck.

Calculate EACH of the following:

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

(b) the distance to the centre of pressure from the upper deck. (8)