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, 22 OCTOBER 2021

0915 - 1215 hrs

Materials to be supplied by examination centres

Candidate's examination workbook Graph paper

Examination Paper Inserts

Worksheet Q3

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

1. A ship 150 m in length floats in sea water of density 1025 kg/m^3. At the load draught, the immersed sectional areas of the main body of the ship are as given in Table Q1A.

Station	AP	½	1	2	3	4	5	6	7	8	9	9½	FP
Immersed section areas (m^2)	4	18	38	75	92	100	105	105	96	66	28	12	6

Table Q1A

Details of hull appendages are as given in Table Q1B.

Item	Volume (m^3)	Centre from midships (m)
Transom stern	15	77 aft
Rudder	6	76 aft
Bulbous bow	12	77 forward

Table Q1B

Calculate EACH of the following:

(a) the displacement; (8)

(b) the longitudinal position of the centre of buoyancy from midships. (8)

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2. For a ship of 5000 tonne displacement floating in water having a density of 1025 kg/m^3, the KG is 5.19 m.

A centre double bottom tank 12.2 m in length, 6.1 m wide and 1.6 m deep is now half filled with oil of density 900 kg/m^3.

A mass of 100 tonne is lifted from a quayside by means of the ship's lifting gear.

The top of the derrick is 18 m above the keel.

The KM in the final condition is 7.5 m.

Calculate EACH of the following:

(a) the final effective metacentric height; (13)

(b) the maximum outreach of the derrick, if the angle of heel is not to exceed 5°. (3)

3. A ship of length 136 m has a light displacement of 4850 tonne with the longitudinal centre of gravity 1.64 m aft of midships.

Loading now takes place as shown in Table Q3.

Load	Mass (tonne)	lcg from midships (m)
cargo	3820	36.55 forward
cargo	3600	31.65 aft
oil fuel	750	3.5 forward
fresh water	120	54.25 forward
stores etc.	60	45.4 aft

Table Q3

Using the relevant data extracted from the hydrostatic curves provided on Worksheet Q3, determine the final end draughts of the vessel in sea water of density 1025 kg/m^3. (16)

4. (a) Describe with the aid of sketches, the influence on a statical stability curve of EACH of the following:

(i) an increase in the breadth of the ship with draught, freeboard and KG remaining constant; (4)

(ii) an increase in the freeboard of the ship with draught, breadth and KG remaining constant; (4)

(iii) an addition of large amounts of deckhouse on the upper deck with draught, breadth, freeboard and KG remaining constant. (4)

(b) A vessel sailing in calm conditions develops an appreciable angle of heel.

There is no bilging.

Explain why this may have occurred stating TWO actions that could be taken to restore the initial upright condition. (4)

5. The hull of a box shaped vessel is 80 m long and has a structural mass of 640 tonne uniformly distributed over its length.

Machinery of mass 200 tonne extends uniformly over the middle 20 m length of the vessel.

TWO holds extending over the extreme forward and aft 20 m lengths of the vessel EACH have 340 tonne of cargo stowed uniformly over their lengths.

(a) Using graph paper, construct curves of EACH of the following:

(i) load per metre; (8)

(ii) shearing force. (4)

(b) Calculate the value of the maximum bending moment. (4)

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6. The force acting normal to the centreline plane of a rudder is given by the expression:

$$F_n = 15.5\ A\ v^2\ \alpha \text{ newtons}$$

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

A ship travelling at a speed of 20 knots, has a rudder configuration as shown in Fig Q6.

The centre of effort for areas A_1 and A_2 are 32% of the width from their respective leading edges.

The rudder angle is limited to 35° from the ship's centreline.

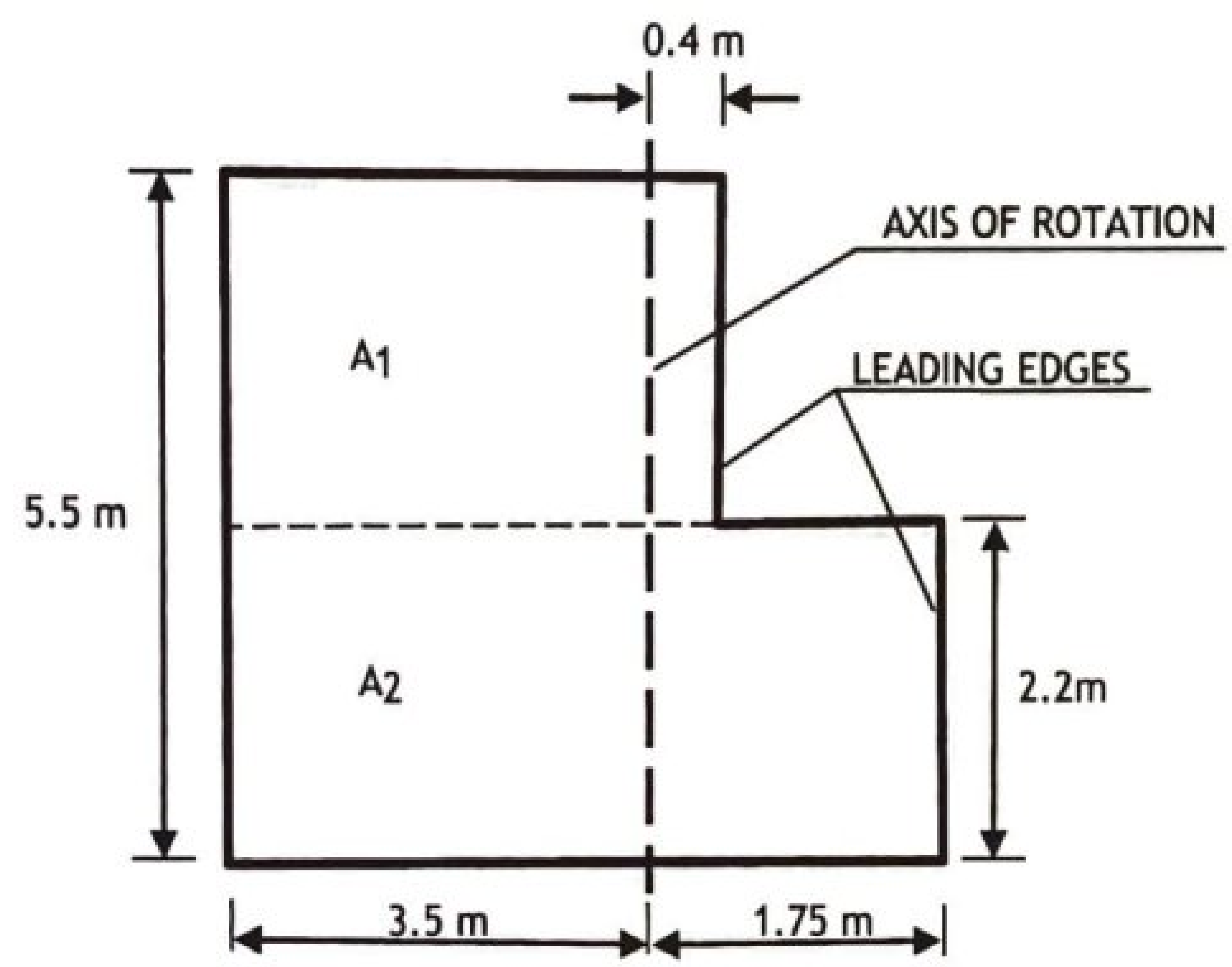

Fig Q6

Calculate EACH of the following:

(a) the diameter of the rudder stock required for a maximum allowable stress of 77 MN/m^2; (12)

(b) the drag component of the rudder force when the rudder is put hard over at full speed. (4)

7. A ship of length 156 m and breadth of 24 m floats at a draught of 8.25 m in sea water of density 1025 kg/m^3. In this condition the block coefficient (C_b) is 0.72.

A geometrically similar model, 6 m in length, gives a total resistance of 43.55 N when tested at a speed of 1.65 m/s in fresh water of 1000 kg/m^3 at a temperature of 12°C.

The following data are also available:

Ship correlation factor = 1.23
Temperature correction = ±0.43% per °C
Wetted surface area (S) = $2.57\sqrt{\Delta L}$ (m^2)
Frictional coefficient for the model in water of density 1000 kg/m^3 at 15°C is 1.655
Frictional coefficient for the ship in water of density 1025 kg/m^3 at 15°C is 1.411
Speed in m/s with index (n) for ship and model 1.825

The ship is travelling at the corresponding speed to the model in sea water of density 1025 kg/m^3 at a temperature of 15°C.

Calculate the effective power of the ship. (16)

8. The following data applies to a ship operating on a particular voyage with a propeller of 6 m diameter having a pitch ratio of 0.9.

propeller speed	=	1.85 revs/s
real slip	=	33%
apparent slip	=	6%
shaft power	=	11000 kW
specific fuel consumption	=	0.205 kg/kW hr

Calculate EACH of the following:

(a) the ship speed in knots; (3)

(b) the Taylor wake fraction; (3)

(c) the reduced speed at which the ship should travel in order to reduce the voyage consumption by 30%; (2)

(d) the voyage distance if the voyage takes 30 hours longer at the reduced speed; (4)

(e) the amount of fuel required for the voyage at the reduced speed. (4)

9. (a) Show that, the position of the centre of pressure for a triangular plane apex down, with its edge in surface, is half of the depth of the plane below the surface. (4)

(b) A bulkhead 7.5 m deep, is in the form of a trapezoid, 13 m wide at the top and 10 m wide at the bottom.

The bulkhead has sea water of density 1025 kg/m^3 on one side to a depth of 5 m.

Calculate EACH of the following:

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

(ii) the position of the centre of pressure. (4)