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, 18 JULY 2025

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

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NAVAL ARCHITECTURE

Attempt SIX questions only.

All questions carry equal marks.

Marks for each part question are shown in brackets.

1. A ship's double bottom tank is divided by an oiltight centre girder to form equal port and starboard tanks.

   The tanks are 16 m long and have a constant plan area defined by equidistant ordinates from the centre girder to the sides of the ship of:

   6.0, 5.5, 4.8, 4.0 and 3.0 metres

   At a displacement of 12000 tonne in sea water of density 1025 kg/m^3, the centre of gravity is 5.8 m above the keel and both tanks are partially full of oil of density 900 kg/m^3 to a depth of 0.8 m.

   Calculate the change in effective metacentric height when all of the oil in both tanks has been consumed, assuming the position of the transverse metacentre to remain constant. (16)

2. For a ship of 6000 tonne displacement floating in water of density 1025 kg/m^3, the KG is 5.5 m.

   A centre double bottom tank 14 m in length, 6.4 m wide and 1.6 m deep is now half filled with oil of density 900 kg/m^3.

   A mass of 120 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.

   If the KM in the final condition is 7.8 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)

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3. A ship of length 130 m has a displacement of 4750 tonne with the longitudinal centre of gravity 0.5 m aft of midships.

Loading now takes place as given in Table Q3.

Load	Mass (tonne)	lcg from midships (m)
cargo	3500	37.5 forward
cargo	4050	29.5 aft
oil fuel	550	14.2 forward
fresh water	100	52.0 forward
stores etc.	50	32.2 aft

Table Q3

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

4. A box shaped vessel 100 m long and 10 m wide floats at an even keel draught of 4 m in sea water of density 1025 kg/m^3 with a KG of 5 m.

A full width, empty compartment has its after bulkhead 20 m forward of midships and its forward bulkhead 30 m forward of midships.

Calculate the end draughts of the vessel if this compartment is bilged. (16)

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5. A box barge of length 50 m is of uniform construction and has a displacement of 600 tonne when empty.

The barge is divided by four transverse bulkheads to form five holds of equal length.

Cargo is loaded as shown in Figure Q5, the cargo in each hold being uniformly distributed.

No. 5 hold	No. 4 hold	No. 3 hold	No. 2 hold	No. 1 hold
400 tonne	300 tonne	400 tonne	500 tonne	300 tonne

AFT FORWARD

Figure Q5

For this condition of loading:

(a) verify that the barge has an even keel draught; (2)

(b) draw to scale EACH of the following:

(i) the load diagram; (6)

(ii) the shear force diagram. (5)

(c) using the diagrams drawn in Q5(b), determine the longitudinal position of the maximum bending moment. (3)

6. A ship of 10000 tonne displacement has a rudder area of 25 m^2. The ship has a KM of 6.9 m, KG of 6.3 m and the centre of lateral resistance is 3.9 m above the keel.

The maximum rudder angle is 35 degrees and the centroid of the rudder is 2.3 m above the keel.

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

$$F = 590\, A\, v^2 \sin \alpha$$

Where: A = rudder area
v = ship speed in m/s
α = rudder helm angle

Calculate EACH of the following, when the vessel is travelling at 22 knots:

(a) the angle and direction of heel due to the rudder force only, if it is put hard over to port; (8)

(b) the angle and direction of heel due to the combination of centrifugal force and rudder force when the rudder is hard over to port and the vessel turns in a circle of 800 m diameter. (8)

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7. When 800 nautical miles from port, the speed of a ship is reduced by 20%, thereby reducing the daily fuel consumption by 42 tonne.

The ship arrives in port with 50 tonne of fuel on board.

The fuel consumption in tonne per hour is given by the expression:

$$C = 0.136 + 0.001\,V^3 \text{ where V is the ship speed in knots.}$$

Determine EACH of the following:

(a) the reduced daily consumption; (6)

(b) the amount of fuel on board when the speed was reduced; (4)

(c) the percentage decrease in fuel consumption for the reduced speed part of the voyage; (4)

(d) the percentage increase in time for this latter part of the voyage. (2)

8. A vessel of 10500 tonne displacement is fitted with a propeller of 5.5 m diameter and pitch ratio 0.9.

During a fuel consumption trial of 6 hours duration, a steady shaft speed of 1.8 rev/s was maintained and 7.54 tonne of fuel was consumed.

The following results were also recorded:

real slip ratio	=	0.34
Taylor wake fraction	=	0.32
shaft power	=	6050 kW
transmission losses	=	3%
quasi-propulsive coefficient (QPC)	=	0.71
propeller thrust	=	680 kN

Calculate EACH of the following:

(a) the speed of the ship; (4)

(b) the apparent slip ratio; (1)

(c) the propeller efficiency; (3)

(d) the thrust deduction fraction; (3)

(e) the fuel coefficient; (3)

(f) the specific fuel consumption. (2)

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9. (a) Define the term *open water efficiency* as applied to a ship's propeller. (1)

(b) Describe the losses that affect the *open water efficiency* of the propeller. (6)

(c) State the causes of ship wake. (3)

(d) Explain the propeller-hull interactions that contribute to the hull efficiency. (6)

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