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, 04 APRIL 2025

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.

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 of length 120 m displaces 11750 tonne when floating in sea water of density 1025 kg/m³.

The centre of gravity is 2.5 m above the centre of buoyancy and the waterplane is defined by the following equidistant half breadths given in Table Q1:

Station	AP	1	2	3	4	5	6	7	FP
Half-breadth (m)	3.3	6.8	7.6	8.1	8.1	8.0	6.6	2.8	0

Table Q1

Calculate EACH of the following:

(a) the area of the waterplane; (3)

(b) the position of the centroid of the waterplane from midships; (3)

(c) the second moment of area of the waterplane about a transverse axis through the centroid; (5)

(d) the moment to change trim one centimetre (MCT 1 cm). (5)

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2. A ship of 12000 tonne displacement floats in sea water of density 1025 kg/m³ at a draught of 6.2 m.

A rectangular tank 8 m long and 10 m wide is partially full of oil fuel of density 900 kg/m³.

In this condition, the KG of the ship is 6.3 m.

Other hydrostatic data for the above condition are:

Centre of buoyancy above the keel (KB)	=	3.4 m
Transverse metacentre above the centre of buoyancy (BM)	=	4.9 m
tonnes per centimetre immersion (TPC)	=	24.6

A rectangular tank 10 m long, 12 m wide and 8 m deep, with its base 1 m above the keel, is filled to a depth of 6 m with sea water ballast.

Calculate the change in effective metacentric height. (16)

Note: Assume the ship to be wall-sided over the affected range of draught

3. A ship of length 130 m is loaded as shown in Table Q3(a)

Item	Mass (tonne)	lcg from midships (m)
lightship	3500	1.85 aft
cargo	8100	3.7 forward
oil fuel	800	6.5 aft
stores	25	13.8 forward
fresh water	25	19.4 forward
crew & effects	10	midships

Table Q3(a)

Table Q3(b) is an extract from the ship's hydrostatic particulars and linear interpolation may be used to obtain data at intermediate draughts.

Draught (m)	Displacement (tonne)	LCB from midships (m)	MCT 1cm (tm)	LCF from midships (m)
8.0	14000	1.8 forward	160	1.52 aft
7.0	11800	2.3 forward	145	1.22 aft

Table Q3(b)

Determine the end draughts of the ship after loading has been completed. (16)

4. A box shaped vessel of length 100 m and breadth 12 m has a full breadth midship compartment 16 m long divided by a centreline watertight bulkhead to form equal tanks port and starboard.

The vessel is loaded to a draught of 6 m in sea water of density 1025 kg/m³ and in this condition the KG is 3.611 m and the midship compartment has a permeability of 80%.

The vessel is now bilged below the waterline on one side only at midships.

Calculate the resulting angle of heel. (16)

5. A uniformly constructed box shaped vessel of length 80 m and breadth 12 m has an even keel draught of 2 m when floating in the light condition in sea water of density 1025 kg/m³.

The vessel has five holds of equal length and is to be loaded with 7000 tonne of cargo, with equal quantities in each of the centre and end holds, and the balance equally distributed in No.2 and No.4 holds.

The cargo in all holds will be trimmed level.

Calculate EACH of the following:

(a) the maximum amount to be loaded in the centre and end holds in order that a maximum hogging bending moment amidships of 4000 tm will not be exceeded; (10)

(b) the resulting shear force at each of the bulkheads. (6)

6. With reference to the testing of a ship model in a towing tank:

(a) define the term *corresponding speed*; (2)

(b) state *Froude's Law of Comparison*; (2)

(c) explain how the effective power of a ship can be estimated from a model test. (12)

7. A ship consumes an average of 60 tonne of fuel per day on main engines at a speed of 16 knots.

The fuel consumption for auxiliary purposes is 8 tonne per day.

When 1000 nautical miles from port it is found that only 160 tonne of fuel remains on board and this will be insufficient to reach port at the normal speed.

Determine the speed at which the ship should travel to complete the voyage with 20 tonne of fuel remaining. (16)

Note: A graphical solution is recommended

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8. A model propeller of mean pitch 0.4 m, is tested in a tank under conditions of constant speed of advance of 2 m/s in fresh water of density 1000 kg/m^3 and the results for a range of rotational speeds are as shown in Table Q8:

Revolutions/s	6	7	8	9	10
Thrust (N)	165	245	355	490	685
Torque (Nm)	13.5	16.0	23.5	34.4	52.2

Table Q8

(a) Plot a curve of propeller efficiency against real slip. (12)

(b) Determine EACH of the following at maximum propeller efficiency:

(i) real slip; (1)

(ii) rotational speed. (3)

9. A watertight door in a bulkhead is 1.2 m high and 0.75 m wide, with a 0.6 m sill.

The bulkhead is flooded with sea water to a depth of 3 m on one side and 1.5 m on the other side.

(a) Draw the load diagram for the door. (8)

(b) From the load diagram drawn in Q9(a) determine:

(i) the resultant load; (3)

(ii) the position of the centre of pressure on the door. (5)