CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY
MARINE ENGINEER OFFICER

EXAMINATIONS ADMINISTERED BY THE
SCOTTISH QUALIFICATIONS AUTHORITY
ON BEHALF OF THE
MARITIME AND COASTGUARD AGENCY

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

040-34 – NAVAL ARCHITECTURE

FRIDAY, 31 MARCH 2017

0915 - 1215 hrs

Examination paper inserts:

Notes for the guidance of candidates:

1. Non-programmable calculators may be used.
2. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Materials to be supplied by examination centres:

Candidate's examination workbook
Graph paper

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/m^3. 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)

2. A vessel has a depth of 10 m and a displacement of 8000 tonne when the metacentric height is 1.2 m and height to the metacentre (KM) is 7.4 m.

Two adjacent rectangular bunkers, extending over the full depth of the vessel, each 10 m long and 6 m wide, are situated either side of the centreline.

Each bunker is full of fuel oil of density 900 kg/m^3.

Fuel is consumed from one bunker until a maximum angle of list of 3° is caused.

Calculate the maximum mass of fuel initially consumed before switching to the other bunker. (16)

Note: KM can be assumed constant.

3. A vessel of constant rectangular section 80 m long and 12 m wide had a KG of 4.77 m and floats on an even keel draught of 5.5 m in water of density 1025 kg/m^3. The vessel is fitted with a transverse watertight bulkhead 10 m from the forward end.

The compartment forward of the transverse bulkhead, which has a permeability of 60%, is now damaged and laid open to the sea.

Calculate the new end draughts of the vessel. (16)

4. A box barge of length 40 m is of uniform construction and has a displacement of 800 tonne when empty.

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

Cargo is loaded as shown in Fig Q4, the cargo in EACH hold being uniformly distributed.

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; (4)

(c) determine the longitudinal position and value of the maximum bending moment, stating whether it is hogging or sagging. (4)

No.4 hold 600 tonne	No.3 hold 200 tonne	No.2 hold 800 tonne	No.1 hold 400 tonne

AFT FORWARD

Fig Q4

5. A ship model of length 6 m has a wetted surface area of 6.62 m^2.

When tested in fresh water of density 1000 kg/m^3, at a speed of 1.8 m/s, the total resistance was measured at 48 N.

This tank speed corresponds with a trial ship speed of 17.5 knots in sea water of density 1025 kg/m^3, which is achieved when the shaft power is 8720 kW, when the propulsive coefficient is 0.67.

Calculate the Ship Correlation Factor (SCF) for the ship in this trial condition. (16)

Note: The frictional coefficient for the model in fresh water is 1.655
The frictional coefficient for the ship in sea water is 1.413
Speed in m/s with the speed index (n) for ship and model 1.825.

6. The following data were obtained during acceptance trials for a ship of 11650 tonne displacement:

ship speed 16 knots
torque delivered to the propeller 340 kNm
propeller thrust 465 kN
propeller speed 1.85 rev/s
effective power 2900 kW
propeller efficiency 67%
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; (4)
(c) the real slip ratio; (1)
(d) the thrust deduction fraction; (3)
(e) the quasi-propulsive coefficient; (2)
(f) the Admiralty Coefficient based upon shaft power. (3)

7. (a) Explain how a propeller blade may be eroded due to cavitation, describing the progressive nature of the damage. (8)

(b) Outline the design features that may be considered to minimise cavitation. (8)

8. A *spade-type* rudder has an area of 6.33 m^2. At its maximum designed rudder angle of 35°, the centre of effort is 0.12 m aft of the axis of rotation and 1.6 m below the lower edge of the rudder stock bearing.

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

$$F_n = 18.32\ A\ v^2\ \alpha \quad \text{newtons}$$

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

The equivalent twisting moment (T_E) is given by:

$$T_E = M + \sqrt{(M^2 + T^2)}$$

where: M = bending moment
T = torque

The maximum stress in the rudder material is to be limited to 77MN/m^2.

Calculate EACH of the following:

(a) the diameter of the rudder stock required for a ship speed of 16 knots; (10)

(b) the speed to which the ship must be restricted, given that the effective diameter of the stock is reduced by wear and corrosion to 375 mm. (6)

9 A watertight door is 1.2 m high and 0.75 m wide, with a 0.6 m still. 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 of the door. (8)

(b) From the load diagram drawn in Q9(a), determine EACH of the following:

(i) the resultant load; (3)

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