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, 23 MARCH 2018

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

NAVAL ARCHITECTURE

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

1. The load waterplane of a ship is 144 m long, floating in sea water of density 1025 kg/m^3, is defined by the half ordinates given in Table Q1:

Station	AP	½	1	2	3	4	5	6	7	7½	FP
Half ordinates (m)	2.0	4.8	6.6	8.7	9.5	9.6	9.5	8.2	4.8	2.4	0

Table Q1

The following particulars are obtained from the ship's hydrostatic curves:

displacement = 13640 tonne
centre of buoyancy above the keel (KB) = 3.84 m
moment to change trim by one centimetre (MCT 1cm) = 176.5 tm

Calculate EACH of the following:

(a) the position of the longitudinal centre of flotation (LCF) from midships; (6)

(b) the second moment of area of the waterplane about a transverse axis through the centroid; (6)

(c) the height of the ship's centre of gravity above the keel (KG). (4)

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)

[OVER

3. A ship of 120 m in length has the following particulars when floating in sea water of density 1025 kg/m^3.

Displacement = 10560 tonne
draught aft = 6.93 m
draught forward = 6.58 m
longitudinal metacentric height (GM_L) = 125 m
centre of flotation from midships (LCF) = 2.4 m aft
tonnes per centimetre immersion (TPC) = 19.9

Two tanks, each containing a substantial quantity of water ballast, are situated with their centres of gravity 30 m aft of midships and 55 m forward of midships.

The vessel is required to enter dock with draught aft 6.60 m and a trim of 0.50 m by the stern.

Calculate the amount of ballast to be discharged from EACH tank. (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/m^3 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) Explain the procedure required to produce weight, buoyancy and load curves for a ship assumed to be floating in still water, stating any relevant features of the curves. (8)

(b) Describe how shear force and bending moment curves are produced from a load diagram, explaining how the features of EACH curve are connected. (8)

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

$F_n = 20.17\ A\ v^2\ \alpha$ newtons

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

A manoeuvrability specification for a ship that requires a *transvers*e rudder force of 75 kN is generated when the angle of helm is 35° with the ship travelling at a speed of 5 knots.

(a) Determine suitable dimensions for a rectangular rudder having a depth to width ratio of 1.6. (6)

(b) The rudder stock is designed to have a diameter of 320 mm with the allowable shear stress in the material limited to 70 MN/m^2 at its service speed of 15 knots.

At the maximum helm angle of 35°, the centre of effort is 34% of the rudder width from the leading edge of the rudder.

Determine the distance of the axis of rotation from the leading edge of the rudder so that the stock is not overstressed at the service speed. (10)

7. A ship of length 140 m and breadth 18 m floats at a draught of 8 m in sea water of density 1025 kg/m^3. In this condition the block coefficient (C_b) is 0.68.

At a speed of 15 knots the following data applies:

Delivered power	=	4720 kw
Quasi-propulsive coefficient (QPC)	=	0.70
Ship correlation factor (SCF)	=	1.18

Calculate the pull required to tow a similar model of length 5 m at the corresponding speed in fresh water density 1000 kg/m^3. (16)

Note: The frictional coefficient to be used:

for the model in fresh water of density 1000 kg/m^3 is 1.694
for the ship in sea water of density 1025 kg/m^3 is 1.415

Speed in m/s with the speed index (n) for ship and model 1.825

Wetted surface area (S) = $2.57\sqrt{\Delta L}$ (m^2)

[OVER

8. A ship of 30800 tonne displacement has a length of 150 m, breadth of 26.5 m and floats at a draught of 10.5 m when in sea water of density 1025 kg/m^3.

The ship's propeller has a diameter of 6.5 m with a pitch ratio of 0.8.

When the propeller is operating at 1.75 revs/sec, the real slip is 32% and the thrust power is 6800 kW.

The thrust power is reduced to 5500 kW and the real slip increases to 35%.

It can be assumed that the thrust power is proportional to (speed of advance)^3.

Calculate EACH of the following for the reduced power:

(a) ship speed; (11)

(b) the propeller speed of rotation; (3)

(c) the apparent slip. (2)

Note: *Wake fraction = 0.5* C_b *- 0.05*

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)