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, 20 OCTOBER 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. At a draught of 1.0 m in sea water of density 1025 kg/m^3 the displacement of a ship is 900 tonne and the height of the centre of buoyancy above the keel (KB) is 0.6 m.

Values of tonne per centimetre immersion (TPC) in sea water for a range of draughts are given in Table Q1.

Draught (m)	1.0	1.5	2.0	3.0	4.0	5.0	6.0
TPC	12.0	12.8	13.4	14.4	15.0	15.5	15.9

Table Q1

(a) Calculate EACH of the following for a draught of 6.0 m in sea water:

(i) the displacement; (4)

(ii) the height of the centre of buoyancy above the keel (KB). (6)

(b) At a draught of 6.0 m, the height of the longitudinal metacentre above the keel (KM_L) is 128 m and the second moment of area of the waterplane about a transverse axis through midships is 996728 m^4.

The centre of flotation is aft of midships.

Calculate the distance of the centre of flotation (LCF) from midships. (6)

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2. Table Q2 gives values of righting levers (GZ) relating to a ship of 12000 tonne displacement in a particular load condition:

Angle of heel (degrees)	0	15	30	45	60	75	90
GZ (m)	0	0.48	1.19	1.49	1.30	0.66	-0.31

Table Q2

In the above condition the ship has 320 tonne of fuel stored in a double bottom tank which has to be emptied for survey. This oil is transferred to a wing deep tank, through a transverse distance of 7.5 m and a vertical height of 5.25 m.

(a) Draw the amended curve of statical stability, neglecting the effects of free surface. (12)

(b) Determine EACH of the following, from the curve drawn in Q2(a):

(i) the angle to which the ship will list; (1)

(ii) the range of stability. (1)

(c) Determine the righting moment at an angle of 25°. (2)

3. For a ship of 3910 tonne light displacement, 140 m in length, the longitudinal centre of gravity (LCG) is 1.75 m aft of midships.

The following items in Table Q3(a) are added:

Item	Mass (tonne)	Lcg from midships (m)
Cargo	10000	3.9 forward
Oil fuel	445	13.1 forward
Fresh water	30	12.4 aft
Stores	20	6.0 forward
Crew & effects	15	midships

Table Q3(a)

The following hydrostatic data in Table Q3(b) can be assumed to have a linear relationship between the draughts shown.

Draught (m)	Displacement (tonne)	LCB from midships (m)	MCT1cm (tm)	LCF from midships (m)
8.0	14850	2.4 forward	182.2	0.30 aft
7.0	12800	2.8 forward	171.5	0.56 forward

Table Q3(b)

Calculate the final end draughts. (16)

4. A box-shaped vessel 80 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 4 m.

A full width, empty compartment has its after bulkhead 20 m aft of midships and its forward bulkhead 10 m aft of midships.

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

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5. A box shaped barge of length 70 m has a hull mass of 560 tonne which is evenly distributed throughout its length.

Bulkheads are located 5 m from the barge ends to form peak tanks which are empty. The remainder of the barge is divided by two transverse bulkheads to form three holds of equal length.

These holds are loaded with a total of 1680 tonne of level stowed bulk cargo, one quarter of which is loaded in the centre hold and the remainder is equally distributed over the two other holds.

Draw EACH of the following curves on a base of ship length:

(a) weight and buoyancy curves; (5)

(b) load curve; (3)

(c) shear force curve; (4)

(d) bending moment curve. (4)

6. A single screw ship with a service speed of 15 knots is fitted with a rectangular rudder, 5.5 m deep and 3.5 m wide, with its axis of rotation 0.4 m from the leading edge.

At a rudder helm angle of 35 degrees, the centre of effort is 32% of the rudder width from the leading edge.

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

$$F = 577\, A\, v^2 \sin \alpha \text{ (newtons)}$$

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

The maximum stress on the rudder stock is to be limited to 70 MN/m^2.

Calculate EACH of the following, for a rudder angle of 35 degrees:

(a) the minimum diameter of the rudder stock for ahead running; (9)

(b) the speed of the ship, when running astern, at which the maximum stress level would be reached. (7)

7. A ship 150 m long has a load displacement of 27500 tonne in sea water of density 1025 kg/m³. To maintain a speed of 16 knots in the above condition of trials, a shaft power of 7860 kW is required.

SCF for trial condition	=	1.08
SCF for service condition	=	1.23
Quasi-propulsive coefficient (QPC)	=	0.70
Transmission losses	=	3%
Wetted surface area (m²)	=	$2.57\sqrt{\Delta L}$

Calculate the shaft power required in service for a geometrically similar ship of 22360 tonne load displacement operating at the corresponding speed. (16)

Note: The frictional coefficient for the 27500 tonne ship in sea water is 1.413
The frictional coefficient for the 22360 tonne ship in sea water is 1.415
The frictional coefficients are to be used with speed in m/s
Speed index (n) is 1.825

8. A model propeller is 0.4 m diameter and has a pitch of 0.4 m.

At a speed of advance of 2 m/s in water of density 1000 kg/m³ and at 6.8 revs/sec, the torque is 40 Nm and the thrust developed is 560 N.

A geometrically similar ship's propeller 5 m in diameter, is operating in water of density 1025 kg/m³ at corresponding linear and rotational speeds.

(a) Calculate EACH of the following for the ship's propeller:

(i) revolutions per second; (1)

(ii) speed of advance; (1)

(iii) real slip; (3)

(iv) delivered power; (3)

(v) propeller efficiency. (4)

(b) Calculate the hull efficiency when the propeller is operating on a vessel at a Taylor wake fraction of 0.25 and a thrust deduction fraction of 0.2. (4)

Note: For similar propellers at corresponding speeds, it can be assumed:
Linear speed is proportional to (diameter)^{½}
Rotational speed is proportional to (diameter)$^{-½}$
Thrust is proportional to (diameter)^{3}
Torque is proportional to (diameter)^{4}

9. (a) Show that, the position of the centre of pressure for a rectangular plane, with its edge in surface, is two thirds of the depth of the plane below the surface. (4)

(b) A rectangular bulkhead 8 m wide has sea water of density 1025 kg/m^3 on one side to a depth of 7 m and oil of density 850 kg/m^3 on the other side to a depth of 4 m.

Calculate EACH of the following:

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

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