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 95 CHIEF ENGINEER REG. III/2 (UNLIMITED)

041-34 – NAVAL ARCHITECTURE

FRIDAY, 27 MARCH 2015

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 160 m displaces 22862 tonne when floating at a draught of 8.526 m in sea water of density 1025 kg/m^3.

   The waterplane area is defined by half breadths as given in Table Q1.

Station	AP	1	2	3	4	5	6	7	8	9	FP
½ Breadth (m)	2	6	9	11	12	12	12	10	7	3	0

Table Q1

   The following tables are partially full of liquid as indicated:

   rectangular tank 10.2 m long and 6 m wide, containing fresh water of density 1000 kg/m^3.
   rectangular tank 7.4 m long and 5 m wide containing oil fuel of density 890 kg/m^3.

   When a mass of 20 tonne is moved a distance of 22 m across the deck, a deflection of 71 mm is recorded on a pendulum of 9.2 m length.

   The height of the centre of buoyancy above the keel (KB) may be determined using Morrish's formula as given below.

$$KB = \frac{5}{6} \times d - \frac{\nabla}{3 \times A_W}$$

   Calculate the KG of the ship in the above condition. (16)

2. A vessel of 14000 tonne displacement floats at a draught of 8 m in sea water of density 1025 kg/m^3.

Further hydrostatic data for the above condition are:

centre of buoyancy above the keel (KB)	=	4.456 m
transverse metacentre above the keel (KM)	=	7.715 m
tonne per centimetre immersion (TPC)	=	20

The vessel in the above condition is unstable and heels to an angle of 6°.

To restore positive stability, ballast of 640 tonne is now loaded at a Kg of 0.6 m.

Calculate EACH of the following for the final condition:

(a) the transverse metacentric height; (13)

(b) the righting moment when the vessel is heeled to an angle of 15°. (3)

Note: The vessel may be considered wall-sided between the limits of draught, hence:

$$GZ = \sin\theta\,(GM + \tfrac{1}{2}\,BM\tan^2\theta)$$

3. The hydrostatic particulars given in Table Q3 are for a ship of length 150 m when floating in water of density 1025 kg/m^3.

Draught (m)	Displacement (tonne)	MCT 1 cm (tm)	LCB from midships (m)	LCF from midships (m)
7.5	18200	216.5	0.85 forward	2.44 aft
7.0	16800	214.0	1.07 forward	2.24 aft

Table Q3

The ship floats in water of density 1015 kg/m^3 with draughts of 7.6 m aft and 6.8 m forward.

Calculate EACH of the following:

(a) the displacement; (8)

(b) the longitudinal position of the ship's centre of gravity. (8)

4. 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 77 MN/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)

5. 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 of density 1000 kg/m^3. (16)

Note:
The frictional coefficient for the model in fresh water of density 1000 kg/m^3 is 1.694
The frictional coefficient 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 $\sqrt{\Delta\, L}(m^2)$

6. The ship data in Table Q6 have been derived from the results of model experiments.

Ship speed (knots)	14	15	16
Effective power (kW)	2680	3460	4690
Thrust deduction fraction	0.195	0.192	0.185
Taylor wake fraction	0.302	0.298	0.292
Propeller efficiency	0.675	0.685	0.680

Table Q6

Using the data in Table Q6, determine EACH of the following:

(a) the ship speed when the propeller is absorbing 5250 kW delivered power; (10)

(b) the propeller speed (rev/sec) given that the propeller has a diameter of 5 m with a pitch ratio of 0.9 and is operating at a real slip of 32 %. (6)

7. (a) Container ships have very large cargo hatch openings.

Describe how this ship type is susceptible to torsion and how the structure is designed to combat torsional stress. (5)

(b) Describe the problem created by discontinuities in longitudinal structure. (2)

(c) State THREE points of discontinuity, in any ship type, describing how the problems are overcome. (9)

8. (a) Explain the requirements of an A-60 fire protection bulkhead. (4)

(b) Describe the structural arrangements for the fire protection of passenger ships. (8)

(c) Describe how the integrity of an 'A' class division is maintained where an opening has been made for an access door. (4)

9. (a) Define *critical temperature* and *boiling point* and hence show how some liquefied gases may be transported fully pressurised, whilst others need to be carried fully refrigerated. (6)

(b) State the basic differences in construction of fully pressurised and fully refrigerated systems for the carriage of liquefied gas at sea. (5)

(c) Compare the membrane tank and independent tank systems of construction. (5)