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 JULY 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 end bulkhead of the wing tank of an oil tanker has the following widths at 3 m intervals, commencing from the deck are 6.0, 6.0 5.3, 3.6 and 0.6 m.

   The tank is full of oil of density 800 kg/m^3.

   Calculate EACH of the following:

   (a) the load on the bulkhead; (8)

   (b) the position of the centre of pressure. (8)

2. A ship of 4000 tonne displacement floats at a mean draught of 6 m in sea water of density 1025 kg/m^3 but is unstable and has an angle of loll.

   Hydrostatic particulars for the ship in the upright condition at the above displacement are as follows:

Centre of buoyancy above the keel (KB)	=	3.225 m
Height of transverse metacentre above the keel (KM)	=	5.865 m
Tonne per centimetre immersion (TPC)	=	8.0

   To achieve a satisfactory stable condition with a metacentric height of 350 mm, a load of 480 tonne at a Kg of 2.5 m is added to the ship on the centreline.

   Calculate, for the original unstable condition, EACH of the following:

   (a) the height of the original centre of gravity above the keel (KG); (12)

   (b) the angle of loll. (4)

   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. A ship of length 140 m has the following hydrostatic particulars when floating at an even keel draught in sea water of density 1025 kg/m^3.

Waterplane area	=	1756 m^2
displacement	=	12194 tonne
longitudinal metacentric height (GM_L)	=	155 m
centre of flotation from midships (LCF)	=	2 m aft

The ship in the above condition grounds on a rock which may be assumed to be at a point 50 m forward of midships and settles such that the end draughts are 6.465 m aft and 5.425 m forward.

Calculate the original even keel draught of the ship. (16)

4. A ship of displacement 14000 tonne has a length 130 m, breadth 17 m, and even keel draught of 6.11 m in sea water of density 1025 kg/m^3. The area of the waterplane is 1600 m^2 and the second moment of area of the waterplane about a transverse axis through midships is 1.25×10^6 m^4 with the LCF at midships.

The ship has a full depth empty rectangular compartment of length 13 m and breadth 11 m. The centre of the compartment is on the centreline of the ship 30 m forward of midships.

Calculate the end draughts after the compartment is bilged. (16)

Note: For the purposes of calculating the MCT1cm it can be assumed that $GM_L = BM_L$

5. A uniformly constructed box shaped vessel of length 60 m and breadth 10 m has an even keel draught of 2 m when floating in the light condition in sea water of density 1025 kg/m^3.

The vessel has five holds of equal length and is to be loaded with 4000 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 3000 tm will not be exceeded; (10)

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

6. (a) Explain how a force normal to the rudder is produced when the rudder is turned to a helm angle. (3)

(b) Define the term *centre of effort* as applied to a rudder. (1)

(c) Describe how the position of centre of effort changes as helm angle increases. (2)

(d) Explain the term *balanced*, describing the benefits of fitting a balanced rudder. (3)

(e) Describe, with the aid of a sketch, how an angle of heel is produced due to the force on the rudder. (7)

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

8. (a) The residuary resistance of a 1/25 scale model of a ship is 7.65 N when tested at 1.75 m/s in fresh water of density 1000 kg/m^3.

The frictional resistance of the ship at 15 knots in sea water of density 1025 kg/m^3 is 185 kN.

Frictional resistance can be assumed to vary with speed to the power 1.825.

Calculate the effective power (naked) for the ship at the speed corresponding to the model test. (8)

(b) The following additional data apply to the ship operating in service at the corresponding speed as calculated in Q6(a), with a propeller having a pitch of 4.75 m.

Appendage and weather allowance	=	23%
Quasi-propulsive coefficient (QPC)	=	0.71
Propeller speed	=	1.9 revs/sec
Taylor wake fraction	=	0.33
Propeller thrust	=	640 kN

Calculate EACH of the following:

(i) the torque delivered to the propeller; (3)

(ii) the propeller efficiency; (3)

(iii) the real slip ratio. (2)

9. (a) Describe how cavitation occurs on a ship's propeller, explaining how it is more likely to occur as draught reduces and sea water temperature increases. (8)

(b) Describe FOUR types of propeller cavitation. (4)

(c) State FOUR detrimental effects of propeller cavitation. (4)