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 CHIEF ENGINEER REG. III/2 (UNLIMITED)

041-34 – NAVAL ARCHITECTURE

FRIDAY, 16 DECEMBER 2016

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 160 m in length has a load displacement of 20500 tonne and floats in water of density 1025 kg/m^3. The load waterplane is defined by equally spaced half breadths as shown in Table Q1.

Section	AP	1	2	3	4	5	6	7	FP
Half-breadth (m)	1	6	10	11	12	11	9	5	0

Table Q1

The following particulars are also available:

centre of buoyancy above the keel (KB) 4.264 m
centre of gravity above the keel (KG) 7.561 m
centre of lateral resistance above the keel 4.050 m

A rectangular tank, partially filled with oil of relative density 0.89 has overall dimensions of 10 m by 10 m, but it is divided into two equal tanks by an oiltight longitudinal bulkhead.

Calculate EACH of the following:

(a) the effective metacentric height; (12)

(b) the angle to which the ship will heel when turning on a circular course of 400 m diameter at a speed of 16 knots. (4)

2. A ship of 25420 tonne displacement floating in sea water has 800 tonne of bunker fuel of density 895 kg/m^3 in double bottom tanks which are pressed up full. In this condition the metacentric height is 0.25 m and the ordinates of the statical stability curve corresponding to this displacement are as follows:

Angle of Heel (degrees)	0	5	10	15	20
GZ (metres)	0	0.012	0.050	0.098	0.160

The oil is transferred to a deep tank 4.85 m long by 18.2 m wide, situated on the ship's centreline. The centre of gravity of the fuel after transfer is 6.8 m above the original centre of gravity of the oil.

Determine EACH of the following, for the new condition:

(a) the final effective metacentric height; (5)

(b) the angle that the ship heels to; (7)

(c) the dynamical stability at 20° angle of heel. (4)

3. A ship of length 110 m has draught marks 4.5 m aft of the forward perpendicular and 5.5 m forward of the after perpendicular. The draughts at the marks are 4.35 m aft and 3.85 m forward.

For this condition, the following hydrostatic data are available:

LCF = 2.25 m aft of midships
Displacement = 6300 tonne
GM_L = 80 m
LCB = 0.6 m aft of midships

Calculate EACH of the following:

(a) the true mean draught; (4)

(b) the draughts at the perpendiculars; (4)

(c) the longitudinal position of the centre of gravity. (8)

4. A single screw vessel with a service speed of 16 knots is fitted with an unbalanced rectangular rudder 6 m deep and 3.5 m wide with an axis of rotation 0.25 m forward of the leading edge.

At the maximum designed rudder angle of 35° the centre of effort is 30% 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:

$$F_n = 20.2\, A\, v^2\, \alpha \quad \text{newtons}$$

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

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

Calculate EACH of the following:

(a) the minimum diameter of rudder stock required; (9)

(b) the percentage reduction in rudder stock diameter that would be achieved if the rudder was designed as a *balanced* rudder, with the axis of rotation 0.85 m from the leading edge. (7)

5. A ship 137 m long displaces 13716 tonne. The shaft power required to maintain a speed of 15 knots is 4847 kW, and the propulsive coefficient based upon shaft power is 0.67.

$$\textit{wetted surface area} = 2.58\sqrt{\Delta L}$$

$$\textit{propulsive coefficient} = ep/sp$$

Values of the Froude friction coefficient for Froude's Formula are given in Fig Q5, with speed in m/s and speed index (n) = 1.825.

Calculate the shaft power for a geometrically similar ship which has a displacement of 18288 tonne, the same propulsive coefficient as the smaller ship, and is run at the corresponding speed. (16)

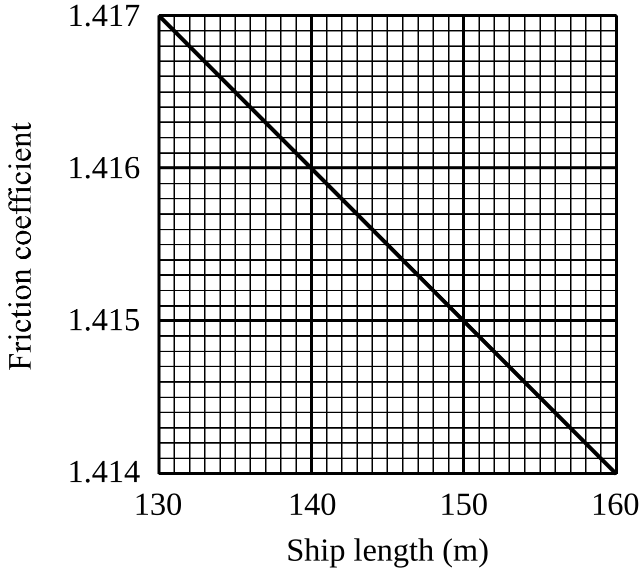

Fig Q5

6. The following data applies to a ship operating on a particular voyage with a propeller of 6 m diameter having a pitch ratio of 0.9:

propeller speed	1.85 revs/s
real slip	33%
apparent slip	6%
shaft power	11000 kW
specific fuel consumption	0.205 kg/kW hr

Calculate EACH of the following:

(a) the ship speed; (3)

(b) the Taylor wake fraction; (3)

(c) the reduced speed at which the ship should travel in order to reduce the voyage consumption by 30%; (2)

(d) the voyage distance if the voyage takes 30 hours longer at the reduced speed; (4)

(e) the amount of fuel required for the voyage at the reduced speed. (4)

7. (a) Explain the circumstances under which whipping stresses may occur in ships. (4)

(b) Describe the use of stress indicators on board a ship. (4)

(c) Sketch a graph of stress versus time indicating whipping. (2)

(d) Describe the structure on a ship that would resist whipping. (6)

8. (a) State the FOUR cargo systems that may be used for the carriage of liquefied gases. (4)

(b) (i) Describe, with the aid of a sketch, a membrane tank containment system suitable for the carriage of liquefied natural gas (LNG). (8)

(ii) Sketch the barrier and insulation system for the membrane tank described in Q8(b)(i). (4)

9. (a) Explain, with the aid of an outline sketch, EACH of the following:

(i) unbalanced rudder; (2)

(ii) semi-balanced rudder; (2)

(iii) balanced rudder. (2)

(b) State the principal advantage of fitting a balanced rudder. (1)

(c) A ship travelling at full speed has its rudder put hard over to port, where it is held until the ship completes a full turning circle.

Describe, with the aid of a sketch, how the ship will heel from the upright condition during the manoeuvre by illustrating the moments produced by the forces acting on the ship and the rudder. (9)