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, 14 DECEMBER 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
Graph paper

NAVAL ARCHITECTURE

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

1. A vessel of 7520 tonne displacement floats in sea water of density 1025 kg/m^3.

A wing deep tank on the vessel is 8 m long, 6 m deep and has a constant plan area formed by the transverse end bulkheads and a longitudinal bulkhead, parallel to and 4 m from the centreline of the ship.

The equally spaced transverse ordinates defining this area are as follows:

4.00, 3.90, 3.70, 3.40 and 3.00 metres.

The base of the tank is 1.2 m above the keel.

With the deep tank full of oil of density 900 kg/m^3, the ship floats upright with a metacentric height of 0.5 m.

40% of the oil in the deep tank is now removed.

Calculate EACH of the following, assuming the KM remains constant at 5.0 m:

(a) the final effective metacentric height; (14)

(b) the final angle of heel. (2)

2. A vessel of 10000 tonne displacement floats at a draught of 7.2 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) = 3.844 m
transverse metacentre above the keel (KM) = 7.186 m
tonne per centimetre immersion (TPC) = 18

The vessel in the above condition is unstable and heels to an angle of 8°.
To restore positive stability, ballast of 540 tonne is now loaded at a Kg of 0.5 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 following particulars apply to a ship of 140 m length when floating in water of density 1025 kg/m^3 at an even keel draught of 7 m.

Displacement	14200 tonne
Centre of gravity above the keel (KG)	8.6 m
Centre of buoyancy above the keel (KB)	4.25 m
Waterplane area	2049 m^2
Centre of flotation from midships (LCF)	4.5 m aft
Second moment of area of the waterplane about a transverse axis through midships	2.332×10^6 m^4

(a) Calculate the moment to change trim by 1 cm (MCT 1cm). (6)

(b) The ship now has the following changes of loading:

143 tonne added with its lcg 10.5 m aft of midships
80 tonne removed with its lcg at midships
60 tonne moved 40 m aft

Calculate the new end draughts of the ship. (10)

4. For a box shaped barge 100 m in length, 15 m breadth, floating at an even keel draught of 8 m in sea water of density 1025 kg/m^3, the KG is 5 m.

A full breadth midship compartment 10 m long is divided by a centreline watertight longitudinal bulkhead to form two equal compartments.

One of the compartments is bilged.

The permeability of the flooded compartment is 85%

Calculate the angle of heel for the barge. (16)

5. A box barge of 64 m length, 8 m breadth and 4.5 m depth has a hull mass of 322 tonne evenly distributed throughout its length. Bulkheads located 2 m from the barge ends, form peak tanks which may be used for ballast. The remainder of the barge length is divided by 4 transverse bulkheads into 5 holds of equal length. The holds are full of bulk cargo having a specific volume of 1.543 m^3/t. The peak tanks are empty.

(a) Calculate the midship bending moment during discharge when both end holds are half empty. (8)

(b) Calculate the minimum depth of sea water ballast which must be added to the peak tanks to allow complete discharge of the end holds if the midship sagging bending moment is to be restricted to a maximum of 19.8 MNm. (8)

6. A ship of 8000 tonne displacement has a rudder area of 22 m^2. The ship has a KM of 6.7 m, KG of 6.1 m and the centre of lateral resistance is 3.8 m above the keel.

The maximum rudder angle is 35 degrees and the centroid of the rudder is 2.3 m above the keel.

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

$$F = 580\ A\ v^2 \sin \alpha$$

Where: A = rudder area
v = ship speed in m/s
α = rudder helm angle

Calculate EACH of the following, when the vessel is travelling at 20 knots:

(a) the angle and direction of heel due to the rudder force only, if it is put hard over to port; (8)

(b) the angle and direction of heel due to the combination of centrifugal force and rudder force when the rudder is hard over to port and the vessel turns in a circle of 800 m diameter. (8)

7. The values of effective power (naked hull) given in Table Q7 refer to a ship which is to have a service speed of 17.75 knots.

Speed (knots)	16.5	17.0	17.5	18.0	18.5
ep_n (kW)	7580	8680	10300	12320	14610

Table Q7

The following data also apply:

appendage allowance	= 8%
weather allowance	= 15%
quasi propulsive coefficient	= 0.7
transmission losses	= 3%
engine mechanical efficiency	= 85%
ratio of service indicated power to maximum indicated power	= 0.9

(a) Determine the indicated power of the engine to be installed. (8)

(b) Determine the speed obtained if all the available power of the engine is used in EACH of the following:

(i) when the ship is running on acceptance trial in calm conditions; (4)

(ii) when operating under actual service conditions. (4)

8. A ship 145 m long and 23 m beam displaces 19690 tonne when floating at a draught of 8 m in sea water density 1025 kg/m^3.

The following data are given for the service speed of 16 knots.

effective power (naked)	3450 kW
appendage and weather allowance	20%
quasi-propulsive coefficient	0.71
thrust deduction fraction	0.21
transmission losses	3%
specific fuel consumption	0.205 kg/kW hr

The Taylor wake fraction is obtained from: $w_t = 0.5\,C_b - 0.05$

(a) Calculate EACH of the following at the service speed:

(i) the delivered power; (2)

(ii) the thrust power; (7)

(iii) the fuel consumption per day. (3)

(b) Calculate the maximum speed at which the ship must travel to complete a voyage of 3000 nautical miles, with only 200 tonne of fuel on board. (4)

9 (a) Show that when a ship is grounded on its centreline during docking, the transverse stability of the ship reduces by: $\frac{P \times KM}{\Delta}$

Where: Δ is the displacement
KM is the distance from keel to metacentre
P is the upthrust at the point of grounding (8)

(b) A vessel 150 m long and 15000 tonne displacement enters dock with draughts 8.6 m aft and 7.7 m forward. KM = 8.5 m and KG = 8.1 m.

MCT 1cm = 130 tm and LCF is 2 m forward of midships.

Calculate the GM at the instant the ship grounds on the blocks (8)