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, 21 OCTOBER 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.

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 126 m long floats at a draught of 7.5 m and in this condition the immersed cross sectional areas and waterplane areas are as given in Tables Q1(a) and Q1(b).

   A_b is the waterplane area at the base.

Section	AP	1	2	3	4	5	FP
Immersed cross section area (m^2)	20	55	110	130	120	85	0

Table Q1(a)

Draught (m)	0	0.75	1.5	3.0	4.5	6.0	7.5
Waterplane area (m^2)	A_b	1000	1240	1510	1600	1680	1720

Table Q1(b)

Calculate EACH of the following:

(a) the base area value A_b; (8)

(b) the longitudinal position of the centre of buoyancy from midships; (4)

(c) the vertical position of the centre of buoyancy above the base. (4)

2. The *wall sided formula* gives an expression for righting lever (GZ) as follows:

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

(a) Derive an expression for the *angle of loll* of a ship which is initially unstable in still water, using the wall sided formula. (5)

(b) A box shaped vessel is 60 m long, 12 m wide and floats at a draught of 5 m in sea water of density 1025 kg/m^3 with a KG of 4.826 m.
A beam wind acts on the exposed area of the vessel causing it to heel to an angle of 15°.

The heeling moment caused by the wind is given by the expression:
Heeling moment = $0.85\ A\ b\ v^2 \cos^2\theta$ Nm

where: A =exposed area = 360 m^2
b = lever = 5.5 m
v = wind speed in m/s
θ = angle of heel in degrees.

Calculate the wind speed using the wall sided formula for GZ. (11)

3. The following particulars apply to a ship of length 140 m when floating in sea water of density 1025 kg/m^3 at an even keel draught of 7.265 m.

Displacement	=	15800 tonne
centre of gravity above the keel (KG)	=	7.8 m
centre of buoyancy above the keel (KB)	=	4.05 m
waterplane area	=	2146 m^2
centre of flotation from midships (LCF)	=	3.0 m aft
second moment of area of the waterplane about a transverse axis through midships	=	$2.305 \times 10^6\ m^4$

(a) Calculate the moment to change trim by one centimetre (MCT 1 cm). (4)

(b) The ship in the above condition now undergoes the following changes in loading:
352 tonne added at an lcg of 10.5 m forward of midships
110 tonne removed from an lcg of 2.0 m aft of midships
150 tonne restowed at a new position 52.7 m aft of its original position.

Calculate EACH of the following for the new condition:

(i) the new end draughts of the ship; (9)

(ii) the longitudinal position at which a mass of 204 tonne should be added to restore the ship to an even keel draught. (3)

4. A box shaped barge of uniform construction is 66 m long and 10 m wide. The barge is divided into three compartments by two transverse watertight bulkheads to form a central compartment and two equal length end compartments.

The barge is loaded with bulk cargo, evenly distributed over the full length of the barge, the resulting permeability of the barge being 60%. The barge floats in river water of density 1008 kg/m^3 with an even keel draught of 5.0 m.

The midship compartment, extending the full width and depth of the barge, is now bilged and the draught increases to 5.5 m.

(a) Determine the length of the midship compartment. (4)

(b) For the final condition:

(i) draw curves of mass and buoyancy distribution; (8)

(ii) determine the longitudinal still water bending moment at midships, stating whether it is hogging or sagging. (4)

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5. Fig Q5 shows the results of progressive speed trials on a ship at a load displacement of 22350 tonne in sea water of density 1025 kg/m^3 with a wetted surface area of 4860 m^2.

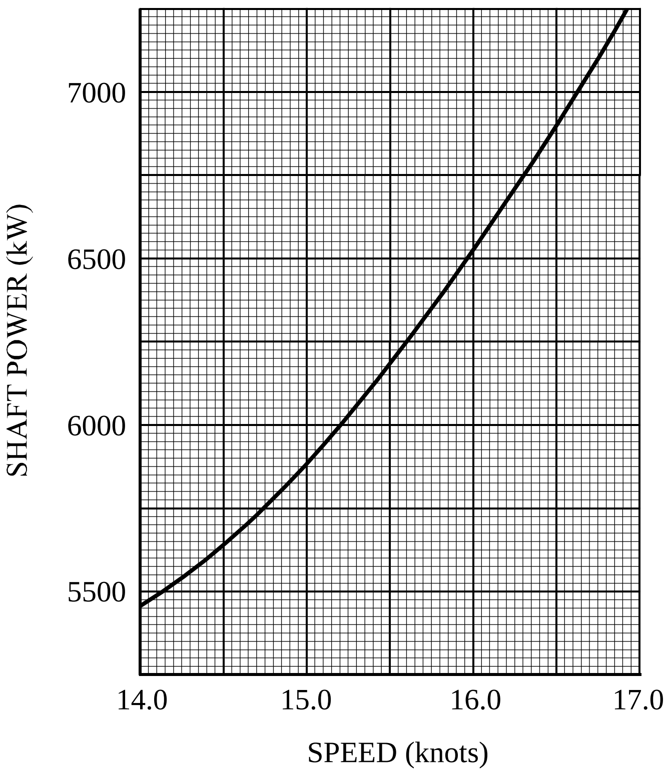

Fig Q5

Using the data given below, calculate the shaft power required to achieve a service speed of 17 knots with a geometrically similar ship having a load displacement of 29245 tonne in sea water. (16)

allowance for appendages and weather in trial condition	8%
allowance for appendages and weather in service condition	20%
propulsive coefficient based upon shaft power for trial and service conditions	0.68

The frictional coefficient for the 22350 tonne ship in sea water is 1.410
The frictional coefficient for the 29245 tonne ship in sea water is 1.406
When speed is in m/s with index (n) = 1.825

6. A vessel of 10500 tonne displacement is fitted with a propeller of 5.5 m diameter and pitch ratio 0.9.

During a fuel consumption trial of 6 hours duration, a steady shaft speed of 1.8 rev/sec was maintained and 7.54 tonne of fuel was consumed.

The following results were also recorded:

Real slip ratio	0.34
Taylor wake fraction	0.32
Shaft power	6050 kW
Transmission losses	3%
Quasi-propulsive coefficient (QPC)	0.71
Propeller thrust	680 kN

Calculate EACH of the following:

(a) the speed of the ship; (4)

(b) the apparent slip ratio; (1)

(c) the propeller efficiency; (3)

(d) the thrust deduction fraction; (3)

(e) the fuel coefficient; (3)

(f) the specific fuel consumption. (2)

7. (a) State FOUR disadvantages of mild steel as a material for ship construction. (4)

(b) Describe materials used as alternatives to mild steel, to overcome some of the disadvantages stated in Q7(a), stating examples of their possible application. (12)

8. (a) With reference to audible noise waves as received by the human ear varying in loudness:

(i) explain how the loudness of the noise varies with respect to a sound wave; (4)

(ii) explain the dB(A) units of noise measurement. (4)

(b) Describe, with the aid of a sketch, how a cabin may be designed to minimise the transmission of sound. (8)

9. (a) Sketch transverse cross sections of a ship, showing the forces acting when the ship is lying at a large angle of heel due to EACH of the following, indicating the positions of the initial and final centres of buoyancy and gravity and the initial position of the transverse metacentre:

(i) an external force (wind or wave); (2)

(ii) a transverse shift of cargo; (2)

(iii) initial instability. (2)

(b) Sketch and label typical statical stability curves for EACH of the following ship loading conditions:

(i) the ship's centre of gravity on the centreline and the ship having a positive metacentric height; (4)

(ii) the ship's centre of gravity off the centreline and the ship having a positive metacentric height; (3)

(iii) the ship's centre of gravity on the centreline and the ship having a negative metacentric height. (3)