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, 18 December 2015

0915 - 1215 hrs

Examination paper inserts:

Worksheet Q2

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 180 m, floats at its load draught with a displacement of 50000 tonne in sea water of density 1025 kg/m^3. The longitudinal centre of buoyancy (LCB) is 1.80 m aft of midships.

   In this condition, the forward half of the ship displaces 23000 tonne and has a centre of displaced volume (lcb) 33.0 m forward of midships. This part of the ship is to be replaced with a new forward half of similar length, but having new immersed cross section areas, to the same load draught, as given in Table Q1.

Section	Midships	6	7	8	9	9½	FP
Section area (m^2)	370	354	330	272	172	95	0

Table Q1

Calculate EACH of the following, for the new condition:

(a) the displacement of the ship; (6)

(b) the longitudinal position of the ship's centre of buoyancy. (10)

2. A ship has a lightship displacement of 9500 tonne and the height of centre of gravity above the keel (KG) is 8.54 m.

Loading now takes place as detailed in Table Q2.

Item	Mass (tonne)	Kg (m)
cargo	21750	9.18
oil fuel	920	2.55
fresh water	250	4.9
stores etc	80	12.3

Table Q2

In this loaded condition, the height of the transverse metacentre above the keel (KM) is 10.38 m.

(a) Using the cross curves of stability provided in Worksheet Q2, construct a curve of statical stability for the loaded vessel. (12)

(b) Using the curve derived in Q2(a), determine the dynamical stability of the vessel up to an angle of 40°. (4)

3. A ship of length 130 m is loaded as shown in Table Q3(a).

Item	Mass (tonne)	Lcg from midships (m)
lightship	3850	1.52 aft
cargo	8645	3.40 forward
oil fuel	860	7.25 aft
stores	35	15.20 forward
fresh water	90	26.80 forward
crew & effects	20	midships

Table Q3(a)

Table Q3(b) is an extract from the ship's hydrostatic particulars and linear interpolation may be used to obtain data at intermediate draughts.

Draught (m)	Displacement (tonne)	LCB from midships (m)	MCT 1cm (tm)	LCF from midships (m)
8.0	14600	2.1 forward	179	0.3 aft
7.0	12600	2.5 forward	167	0.5 forward

Table Q3(b)

Determine the end draughts of the ship after loading has been completed. (16)

4. A single screw ship with a service speed of 16 knots is fitted with a rectangular rudder, 6.5 m deep and 4 m wide, with its axis of rotation 0.4 m from the leading edge.

At a rudder helm angle of 35 degrees, the centre of effort is 32% of the rudder width from the leading edge.

The force (F) on the rudder normal to the plane of the rudder is given by the expression:

$$F = 577\ A\ v^2 \sin \alpha \quad \text{(newtons)}$$

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

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

Calculate EACH of the following, for a rudder angle of 35 degrees:

(a) the minimum diameter of the rudder stock for ahead running; (9)

(b) the speed of the ship, when running astern, at which the maximum stress level would be reached. (7)

5. A ship of length 145 m and breadth 23 m floats at a draught of 10 m in sea water of density 1025 kg/m^3 with a block coefficient of 0.72.

A geometrically similar model 5 m in length, when tested at a speed of 1.48 m/s in fresh water of density 1000 kg/m^3 gives a total resistance of 29.25 N.

Using the data given below, determine the service delivered power for the ship at the corresponding speed to that of the model. (16)

allowance for appendages	=	5%
allowance for weather	=	16%
quasi-propulsive coefficient (QPC)	=	0.71

The frictional coefficient for the model in fresh water is 1.694
The frictional coefficient for the ship in sea water is 1.414
When speed is in m/s with index (n) = 1.825
Wetted surface area (m^2) = 2.57 $\sqrt{\Delta \times L}$.

6. A ship 156 m in length, 22 m breadth, displaces 19700 tonne when floating at a draught of 8 m in sea water of density 1025 kg/m^3.

The ship's propeller has a diameter of 5.5 m, a pitch ratio of 0.9 and a blade area ratio of 0.45.

With the propeller operating at 1.8 rev/sec, the following results were recorded:

apparent slip ratio	=	0.05
thrust power	=	3250 kW
propeller efficiency	=	66%

Calculate EACH of the following for the above condition:

(a) the ship's speed; (3)

(b) the real slip ratio; (6)

(c) the thrust per unit area of blade surface; (4)

(d) the torque delivered to the propeller. (3)

The Taylor wake fraction is given by: $w_t = 0.5\ C_b - 0.05$

7. With reference to fatigue failure:

(a) state the conditions that must be present so that a fatigue failure may be initiated; (3)

(b) sketch a typical fatigue curve (S versus N curve) for a material exhibiting a *fatigue limit*; (3)

(c) state the final fracture mechanism that results from a fatigue failure, describing the factors that contribute to this final failure; (5)

(d) describe, with reasons, which regions of the hull may be susceptible to fatigue failure. (5)

8. (a) Describe TWO functions that trials data fulfils on a newly built ship, other than for satisfying owners of ship performance at sea. (4)

(b) State the TWO types of speed trial carried out. (2)

(c) State the requirements of a measured mile trials course. (4)

(d) List the conditions to be satisfied on a speed trials run. (4)

(e) Explain why trial runs are carried out in double runs. (2)

9. With reference to watertight sub-division of a ship:

(a) describe the purpose of watertight bulkheads; (2)

(b) define EACH of the following terms:

(i) bulkhead deck; (1)

(ii) margin line; (1)

(iii) floodable length; (1)

(iv) permissible length; (1)

(v) factor of sub-division. (1)

(c) state the criterion that decides whether or not a ship has foundered; (1)

(d) state the TWO variables that the factor of sub-division depends upon; (2)

(e) describe the stability requirements with respect to metacentric height and angle of list for a vessel that has sustained *reasonable* damage. (6)