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, 19 JULY 2013

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 *spade type* rudder, supported only at the rudder head, has a depth of 4.8 m, with the following widths at equal intervals commencing from the top of the rudder.

   2.80, 2.75, 2.40, 1.95 and 1.50 m

   The top of the rudder is 0.4 m from the bearing at the rudder head.

   The centre of effort of the rudder can be taken to act at the vertical centroid of the rudder and at a distance of 0.2 m from the axis of rotation.

   The force on the rudder, normal to the plane of the rudder is given by the expression:

   $$F_n = 18 \, A \, v^2 \, \alpha \text{ newtons}$$

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

   The equivalent twisting moment (T_E) is given by:

   $$T_E = M + \sqrt{M^2 + T^2}$$

   where: M = bending moment
   T = twisting moment

   Calculate the required diameter of the rudder stock, assuming a maximum allowable stress of 75 MN/m^2, for a ship speed of 20 knots and rudder angle 35°. (16)

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2. A ship of 31500 tonne displacement floating in sea water has 900 tonne of bunker fuel of density 800 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	0.017	0.055	0.095	0.137

The oil is transferred to a deep tank 5 m long by 20 m wide, situated on the ship's centreline.

The centre of gravity of the fuel after transfer is 7.0 m above the original centre of gravity of the oil.

Calculate 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 240 m has draught marks 6.0 m aft of the forward perpendicular and 10.0 m forward of the after perpendicular. The draughts at the marks are 8.8 m aft and 7.6 m forward. For this condition, the following hydrostatic data are available:

LCF	=	2.4 m aft of midships
Displacement	=	65000 tonne
GM_L	=	120 m
LCB	=	1.4 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 box shaped vessel of length 100 m and breadth 12 m has a full breadth midship compartment 16 m long divided by a centreline watertight bulkhead to form equal tanks port and starboard.

The vessel is loaded to a draught of 6 m in sea water of density 1025 kg/m^3 and in this condition the KG is 3.611 m and the midship compartment has a permeability of 80%.

The vessel is now bilged below the waterline on one side only at midships.

Calculate the resulting angle of heel. (16)

5. A ship model of length 5 m has a wetted surface area of 4.55 m^2. When tested in fresh water of density 1000 kg/m^3, at a speed of 1.646 m/s, the total resistance was measured at 26.25 N.

This model speed corresponds with a trial ship speed of 16 knots in sea water of density 1025 kg/m^3, which is achieved when the shaft power is 4330 kW, when the propulsive coefficient is 0.68.

Calculate the Ship Correlation Factor (SCF) for the ship in this trial condition. (16)

Note: The frictional coefficient for the model in fresh water is 1.694
The frictional coefficient for the ship in sea water is 1.42
Speed in m/s with the speed index (n) for ship and model 1.825

6. A model propeller of 0.4 m diameter and 0.95 pitch ratio, is tested under conditions of constant speed of advance of 1.25 m/s in fresh water of density 1000 kg/m^3. The thrust and torque values for a range of rotational speeds are given in Table Q6.

Rev/sec	4.2	4.4	4.6	4.8	5.0
Thrust (N)	41.0	54.1	68.0	82.5	99.0
Torque (Nm)	2.82	3.52	4.23	4.94	5.73

Table Q6

(a) Draw curves of propeller efficiency and delivered power against real slip ratio for the model propeller. (9)

(b) Using the curves drawn in Q6(a), determine EACH of the following:

(i) the model propeller rotational speed for maximum efficiency; (4)

(ii) the delivered power for a geometrically similar ship's propeller of 6.5 m diameter, operating in sea water of density 1025 kg/m^3 at a real slip ratio of 0.3, given that delivered power is proportional to $(\text{diameter})^{3.5}$. (3)

7. (a) With reference to ship hull vibration, explain, with the aid of a diagram, EACH of the following terms:

(i) two-node vertical mode; (3)

(ii) three-node horizontal mode. (3)

(b) With reference to propeller excited vibration:

(i) state the factors that may lead to its occurrence; (4)

(ii) explain how it may be minimised in design and operation. (4)

(c) A vessel has a natural 2 node frequency of 80 cycles per minute and shaft revolutions are 90 revs per minute. It is proposed to move ballast from a midship tank to two tanks, one being a quarter of the ship's length forward of midships and the other being a quarter of the ship's length aft of midships.

Explain whether this would be an advisable move or not. (2)

8. State the problems associated with the carriage of EACH of the following products, describing the precautions necessary for the safe transportation of EACH:

(a) grain; (4)

(b) timber on deck; (4)

(c) iron ore; (4)

(d) concentrates (finely grained minerals) containing a proportion of moisture. (4)

9. With reference to lifeboat gravity davits, explain, with the aid of a sketch, EACH of the following, stating how they are tested:

(a) the manual braking arrangement when lowering; (5)

(b) the centrifugal braking system; (5)

(c) the roller ratchet system used for raising the lifeboat. (6)