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, 21 JULY 2017

0915 - 1215 hrs

Examination paper inserts:

Worksheet Q3

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 3.6 m, with the following widths at equal intervals commencing from the top of the rudder:

   2.10 m, 2.05 m, 1.80 m, 1.45 m and 1.00 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 0.15 m from the axis of rotation.

   The force on the rudder (F_n), 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 70 MN/m^2, for a ship speed of 18 knots and rudder angle 35°. (16)

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2. A vessel floating in sea water of density 1025 kg/m³ with a displacement of 6600 tonne has the following particulars:

Mean draught	7.0 m
Centre of buoyancy above the keel (KB)	3.845 m
Transverse metacentre above the centre of buoyancy (BM)	4.025 m
Transverse metacentric height (GM)	0.850 m
Tonne per centimetre immersion (TPC)	16

Assuming the vessel to be wall-sided over the affected range of draught, calculate the mass to be added to the vessel at a KG of 2.5 m, to give a final transverse metacentric height of 1.2 m. (16)

3. A ship of length 136 m has a light displacement of 4850 tonne with the longitudinal centre of gravity 1.64 m aft of midships.

Loading now takes place as given in Table Q3:

Load	**Mass (tonne)**	**Lcg from midships (m)**
Cargo	3820	36.55 forward
Cargo	3600	31.65 aft
Oil Fuel	750	3.50 forward
Fresh Water	120	54.25 forward
Stores etc	60	45.40 aft

Table Q3

Determine the final end draughts of the vessel in sea water of density 1025 kg/m³ using the relevant data extracted from the hydrostatic curves provided on Worksheet Q3. (16)

4. A ship of displacement 6600 tonne in sea water of density of 1025 kg/m^3 has a breadth of 16 m and a draught of 5.6 m.

The area of waterplane is 1600 m^2, KB is 3.4 m, KG is 5.1 m and the second moment of area of the waterplane about the centreline is 23180 m^4.

A rectangular wing tank of length 12 m and breadth 4 m is situated above a double bottom of depth 1.2 m as shown in Fig Q4.

Calculate the angle of heel that would occur if the wing tank were bilged. (16)

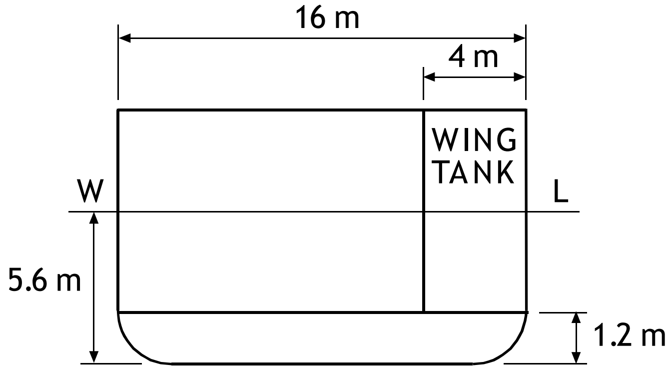

Fig Q4

5. A ship has a length of 130 m and floats in the sea water of density 1025 kg/m^3. A model of this ship has a length of 5 m and a wetted surface area of 6 m^2. The model has a total resistance of 45 N when towed at 1.85 m/s in fresh water of density 1000 kg/m^3.

(a) Using the data below, calculate EACH of the following:

(i) the ratio of residuary resistance to total resistance for the model; (5)

(ii) the ratio of residuary resistance to total resistance for the ship at the corresponding speed. (8)

(b) State why the two ratios should be different. (3)

The frictional coefficient for the model in fresh water is 1.694
The frictional coefficient for the ship in sea water is 1.418
Speed in m/s with the speed index (n) for ship and model 1.825

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6. A model propeller of mean pitch 0.4 m, is tested in a tank under conditions of constant speed of advance 2 m/s in fresh water of density 1000 kg/m^3 and the results for a range of rotational speeds are as shown in Table Q6.

Revs/sec	6	7	8	9	10
Thrust (N)	165	245	355	490	685
Torque (Nm)	13.5	16.0	23.5	34.4	52.2

Table Q6

(a) Plot a curve of propeller efficiency against real slip. (12)

(b) Determine EACH of the following at maximum propeller efficiency:

(i) real slip; (1)

(ii) rotational speed. (3)

7. A box shaped barge of length 70 m has a hull mass of 420 tonne which is evenly distributed throughout its length.
Bulkheads are located 5 m from the barge ends to form peak tanks which are empty.
The remainder of the barge is divided by two transverse bulkheads to form three holds of equal length.
These holds are loaded with a total of 1680 tonne of level stowed bulk cargo, 480 tonne of which is loaded in the centre hold and the remainder is equally distributed in the other two holds.

Draw EACH of the following curves on a base of ship length:

(a) weight and buoyancy curves; (5)

(b) load curve; (3)

(c) shear force curve; (4)

(d) bending moment curve. (4)

8. (a) Describe how a ship's propeller produces thrust. (4)

(b) Explain how the action of producing thrust may lead to propeller cavitation. (3)

(c) State the origin of vortex cavitation from the propeller cone. (1)

(d) Explain how a propeller blade may be eroded due to cavitation, describing the progressive nature of the damage. (8)

9. A ballast tank watertight bulkhead 6.0 m deep is stiffened by vertical angle bar stiffeners 255 mm x 100 mm x 12.5 mm thick, spaced 0.6 m apart.

The ends of the stiffeners in contact with the tank top are welded all around as shown in Fig Q9 and the thickness of the weld is 5 mm.

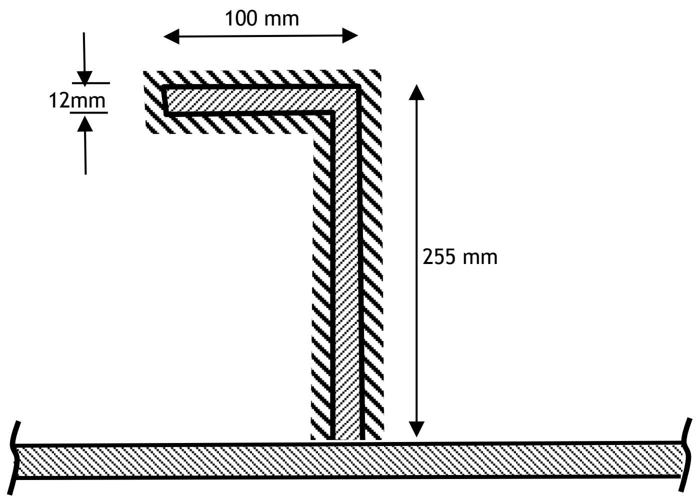

Fig Q9

The bulkhead has sea water of density 1025 kg/m^3 on one side to a depth of 4.85 m.

Calculate the shear stress in the weld metal.

(16)