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 OCTOBER 2012

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 RO-RO ferry of length 80 m has a displacement of 3800 tonne in sea water of density 1025 kg/m^3 with BM = 3.4 m.
The breadth of the ship at the waterline, between sections 3 and 7 is constant at 13 m.
To increase stability, *sponsons*, 1.8 m deep and of constant plan area are to be fitted as shown in Fig Q1.

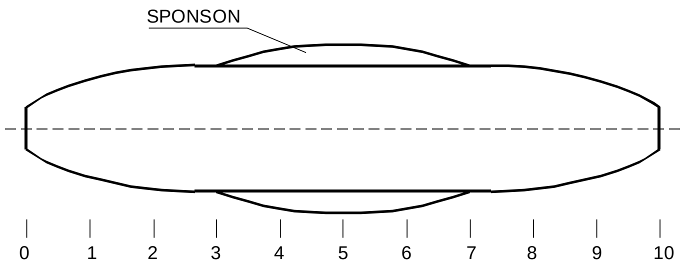

Fig Q1

The sponsons extend over the midship length between sections 3 and 7, with sponson widths as shown in Table Q1.

Section	3	4	5	6	7
Sponson width (m)	0	1.2	1.8	1.2	0

Table Q1

For the new condition there is no change in draught and the load waterline is at mid-depth of the sponson.

Calculate the increase in BM due to the sponsons. (16)

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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 designed to carry timber, is 80 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 4.815 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 = 627 m^2
b = lever = 6.5 m
v = wind speed in m/s
θ = angle of heel in degrees.

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

3. A ship of displacement 11000 tonne has a length 120 m, breadth 16 m, and even keel draught of 5.5 m in sea water of density 1025 kg/m^3. The area of the waterplane is 1440 m^2 and the second moment of area of the waterplane about a transverse axis through midships is 1.2×10^6 m^4 with the LCF at midships.

The ship has a full depth empty rectangular compartment of length 12 m and breadth 10 m. The centre of the compartment is on the centreline of the ship 40 m forward of midships.

Calculate the end draughts after the compartment is bilged. (16)

Note: For the purposes of calculating the MCT1cm it can be assumed that $GM_L = BM_L$

4. A single screw vessel with a service speed of 15 knots is fitted with an unbalanced rectangular rudder 6 m deep and 4 m wide with an axis of rotation 0.2 m forward of the leading edge. At the maximum designed rudder angle of 35° the centre of effort is 30% of the rudder width from the leading edge.

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

$$F_n = 20.2\ A\ v^2 \alpha \quad \text{newtons}$$

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

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

Calculate EACH of the following:

(a) the minimum diameter of rudder stock required; (9)

(b) the percentage reduction in rudder stock diameter that would be achieved if the rudder was designed as a *balanced* rudder, with the axis of rotation 1.0 m aft of the leading edge. (7)

5. The values of effective power (naked hull) given in Table Q5 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 Q5

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 installed machinery 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)

6. A ship 160 m in length, 24 m breadth, displaces 24800 tonne when floating at a draught of 9 m in sea water of density 1025 kg/m^3.

The ship's propeller has a diameter of 5.8 m, a pitch ratio of 0.9 and a blade area ratio of 0.45.

With the propeller operating at 1.9 rev/sec, the following results were recorded:

apparent slip ratio	=	0.06
thrust power	=	3800 kW
propeller efficiency	=	64%

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

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)

7. (a) The stresses acting on a ship in its lifetime can be divided into two categories, with respect to still water stresses and dynamic stresses.

State the different stresses in EACH category, explaining how EACH stress is caused. (10)

(b) Explain how the structure is designed to combat longitudinal stresses. (6)

8. With reference to the fire resistant divisions of a ship:

(a) describe the standard fire test; (3)

(b) define an incombustible material; (2)

(c) explain the essential differences between *A and B class bulkheads*; (8)

(d) state the only requirement of a *C class bulkhead*; (1)

(e) state the requirements of a ventilation duct passing through an *A class bulkhead*. (2)

9. (a) Explain, with the aid of an outline sketch, EACH of the following:

(i) balanced rudder; (2)

(ii) semi-balanced rudder; (2)

(iii) unbalanced rudder. (2)

(b) State the principal advantage of fitting a balanced rudder. (1)

(c) A ship travelling at full speed has its rudder put hard over to port, where it is held until the ship completes a full turning circle.

Describe, with the aid of a sketch, how the ship will heel from the upright condition during the manoeuvre by illustrating the moments produced by the forces acting on the ship and the rudder. (9)