

**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:

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Notes for the guidance of candidates:

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| <ol style="list-style-type: none">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. |
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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 $BM = 3.4 \text{ m}$.
 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.

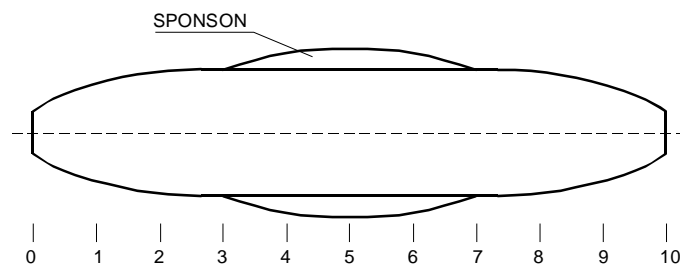


Fig Q1

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)

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

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

- (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/m³ 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:

$$\text{Heeling moment} = 0.85 A b v^2 \cos^2 \theta \text{ Nm}$$

where: A = exposed area = 627 m²
 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/m³. The area of the waterplane is 1440 m² and the second moment of area of the waterplane about a transverse axis through midships is $1.2 \times 10^6 \text{ m}^4$ 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/m³.

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)