CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY
MARINE ENGINEER OFFICER

STCW 78 as amended MANAGEMENT ENGINEER REG. III/2 (UNLIMITED)

040-34 - NAVAL ARCHITECTURE

FRIDAY, 18 OCTOBER 2019

0915 - 1215 hrs

Materials to be supplied by examination centres

Candidate's examination workbook Graph paper

Examination Paper Inserts

Notes for the guidance of candidates:

1. Examinations administered by SQA on behalf of the Maritime & Coastguard Agency.
2. Candidates should note that 96 marks are allocated to this paper. To pass, candidates must achieve 48 marks.
3. Non-programmable calculators may be used.
4. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Maritime & Coastguard Agency

SQA

NAVAL ARCHITECTURE

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

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1. A vessel of SWATH (small waterplane area twin hull) design, has the following hydrostatic particulars when floating in water of density 1025 kg/m^3:

Displacement	= 1390 tonne
centre of buoyancy above the keel (KB)	= 2.744 m
centre of gravity above the keel (KG)	= 6.837 m

The distance between the centrelines of each hull is 12 m and the half breadths of each hull, measured at equal intervals along the 72 m length of waterplane, are as shown in Table Q1.

Station	0	1	2	3	4	5	6	7	8
½ Breadth (m)	0	0.6	1.0	1.3	1.4	1.3	1.0	0.6	0

Table Q1

Calculate the transverse metacentric height of the vessel in the above condition. (16)

2. (a) Sketch and clearly label a statical stability curve for a vessel with its centre of gravity on the centreline but having a negative metacentric height when in the upright condition. (3)

(b) The ordinates for part of a statical stability curve for a bulk carrier at a displacement of 18 000 tonne are given in Table Q2.

Angle (degrees)	0	10	20	30	45	60
Righting lever GZ (m)	0	0.447	0.983	1.396	1.627	1.467

Table Q2

The ship has a hold 40 m long and 30 m wide which contains bulk grain towed at a stowage rate of 1.25 m^3/tonne.

During a heavy roll, the grain shifts so that the level surface is lowered by 1.5 m on one side and raised by 1.5 m on the other side.

(i) Plot the amended statical stability curve for the ship. (12)

(ii) Determine the angle of list due to the cargo shift, from the curve. (1)

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3. A ship 150 m in length displaces 14000 tonne and floats at draughts of 6.25 m forward and 6.6 m aft.

The longitudinal metacentric height is 165 m, the centre of flotation is 1.8 m aft of midships and the TPC is 22.

The vessel is required to enter dock with a draught aft of 6.5 m and a trim of 1 m by the stern.

Calculate EACH of the following:

(a) the mass of ballast to be discharged; (6)

(b) the distance of its centre of gravity from midships. (10)

4. (a) Define the term *open water efficiency* as applied to a ship's propeller. (1)

(b) Describe the losses that affect the open water efficiency of the propeller. (6)

(c) State the causes of *ship wake*. (3)

(d) Explain the propeller-hull interactions that contribute to the hull efficiency. (6)

5. A rectangular oil barge of light displacement 300 tonne is 60 m long and 10 m wide. The barge is divided by four transverse bulkheads into five compartments of equal length.

When compartments 2 and 4 contain equal quantities of oil and the other compartments are empty, the barge floats at a draught of 3 m in fresh water of density 1000 kg/m^3.

(a) Plot EACH of the following curves on a base of barge length:

(i) curve of loads; (4)

(ii) curve of shearing forces; (4)

(iii) curve of bending moments. (5)

(b) State the magnitude and position of the maximum bending moment. (3)

6. A single screw vessel with a service speed of 16 knots is fitted with an unbalanced rectangular rudder 6 m deep and 3.5 m wide with an axis of rotation 0.25 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 0.85 m from the leading edge. (7)

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⑦ The following data refer to two geometrically similar ships:

Ship	Length (m)	Wetted Surface area (m^2)	Displacement (tonne)	Friction coefficient f (sea water)	Speed index n
Ship A	122	2680	8775	1.4275	1.825
Ship B			16250	1.4213	1.825

Fig Q7 shows the results of a progressive speed trial for Ship A.

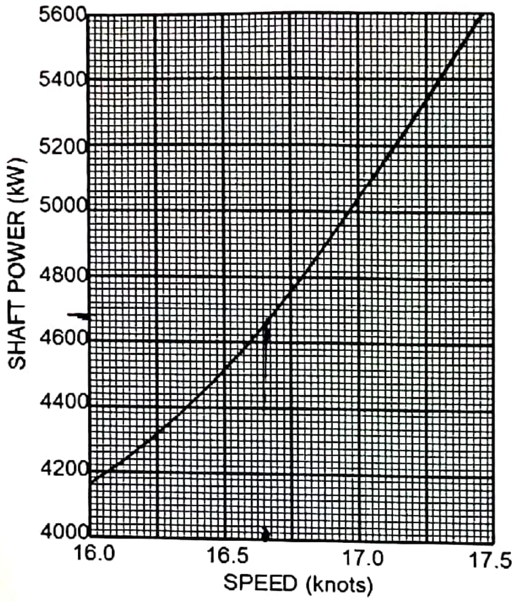

Fig Q7

Calculate the shaft power required for Ship B travelling at a speed of 18.5 knots, given that the propulsive coefficient for both ships is 0.6. (16)

Note: friction coefficient to be used with speed in m/s

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8. A vessel of 10500 tonne displacement is fitted with a propeller of 5.5 m diameter and pitch ratio 0.9.

During a fuel consumption trial of 6 hours duration, a steady shaft speed of 1.8 revs/sec was maintained and 7.54 tonne of fuel was consumed.

The following results were also recorded:

real slip ratio	= 0.34
Taylor wake fraction	= 0.32
shaft power	= 6050 kW
transmission losses	= 3%
quasi-propulsive coefficient (QPC)	= 0.71
propeller thrust	= 680 kN

Calculate EACH of the following:

(a) the speed of the ship; (4)

(b) the apparent slip ratio; (1)

(c) the propeller efficiency; (3)

(d) the thrust deduction fraction; (3)

(e) the fuel coefficient; (3)

(f) the specific fuel consumption. (2)

9. (a) Show that the position of the centre of pressure, for a circular plane with its edge in surface, is $^5/_8$ of the depth of the plane below the surface. (6)

(b) A circular cross-flooding duct between port and starboard wing tanks is 400 mm in diameter and is closed by a gate valve. One tank is empty and the other has sea water of density 1025 kg/m^3 to a head of 1 m above the duct.

Calculate EACH of the following:

(i) the load on the gate valve; (4)

(ii) the position of the centre of pressure on the valve. (6)