13

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, 16 JULY 2021

0915 - 1215 hrs

Materials to be supplied by examination centres

Candidate's examination workbook
Graph paper

Examination Paper Inserts

Worksheet Q2 - Cross Curves

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

All formulae used must be stated and the method of working and all intermediate steps must be made clear in the answer.

1. The load waterplane of a ship 144 m long, floating in sea water of density 1025 kg/m^3, is defined by the half ordinates given in Table Q1:

Station	AP	½	1	2	3	4	5	6	7	7½	FP
Half ordinates(m)	2.0	4.8	6.6	8.7	9.5	9.6	9.5	8.2	4.8	2.4	0

Table Q1

The following particulars are obtained from the ship's hydrostatic curves:

Displacement = 13640 tonne
centre of buoyancy above the keel (KB) = 3.84 m
moment to change trim by one centimetre (MCT 1cm) = 176.5 tm

Calculate EACH of the following:

(a) the position of the longitudinal centre of flotation (LCF) from midships; (6)

(b) the second moment of area of the waterplane about a transverse axis through the centroid; (6)

(c) the height of the ship's centre of gravity above the keel (KG). (4)

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2. A ship has a lightship displacement of 9500 tonne and the height of centre of gravity above the keel (KG) is 8.54 m.

Loading now takes place as detailed in Table Q2.

Item	Mass (tonne)	Kg (m)
cargo	21750	9.18
oil fuel	920	2.55
fresh water	250	4.9
stores etc	80	12.3

Table Q2

In this loaded condition, the height of the transverse metacentre above the keel (KM) is 10.38 m.

(a) Draw a curve of statical stability for the loaded vessel, using the cross curves of stability provided in Worksheet Q2. (12)

(b) Using the curve derived in Q2(a), determine the dynamical stability of the vessel up to an angle of 40°. (4)

3. A ship of length 110 m has draught marks 4.5 m aft of the forward perpendicular and 5.5 m forward of the after perpendicular. The draughts at the marks are 4.35 m aft and 3.85 m forward. For this condition, the following hydrostatic data are available:

LCF = 2.25 m aft of midships
Displacement = 6300 tonne
GM_L = 80 m
LCB = 0.6 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) Explain the procedure required to produce weight, buoyancy and load curves for a ship assumed to be floating in still water, stating any relevant features of the curves. (8)

(b) Describe how shear force and bending moment curves are produced from a load diagram, explaining how the features of EACH curve are connected. (8)

6. 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)

7. A ship model of length 5 m has a wetted surface area of 4.6 m^2.

When tested in fresh water of density 1000 kg/m^3, at a speed of 1.75 m/s, the total resistance was measured at 35 N.

This tank speed corresponds with a trial ship speed of 17 knots in sea water of density 1025 kg/m^3, which is achieved when the shaft power is 6000 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 1.419
Speed in m/s with the speed index (n) for ship and model 1.825

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8. (a) With respect to a ships propeller, explain the term *thrust deduction*. (3)

(b) The following data were obtained during a ships acceptance trials:

ship speed	= 15.4 knots
delivered power	= 2500 kW
effective power	= 1730 kW
thrust	= 274 kN
propeller efficiency	= 64%
apparent slip	= 5%

Calculate EACH of the following:

(i) the thrust deduction fraction; (3)

(ii) the Taylor wake fraction; (5)

(iii) the true slip; (3)

(iv) the hull efficiency. (2)

9. A partially loaded ship with a displacement of 8400 tonne has a length on the waterline of 130 m and LCG 0.9 m aft of midships.

The ship is trimmed by the stern and is dry docked in this condition.

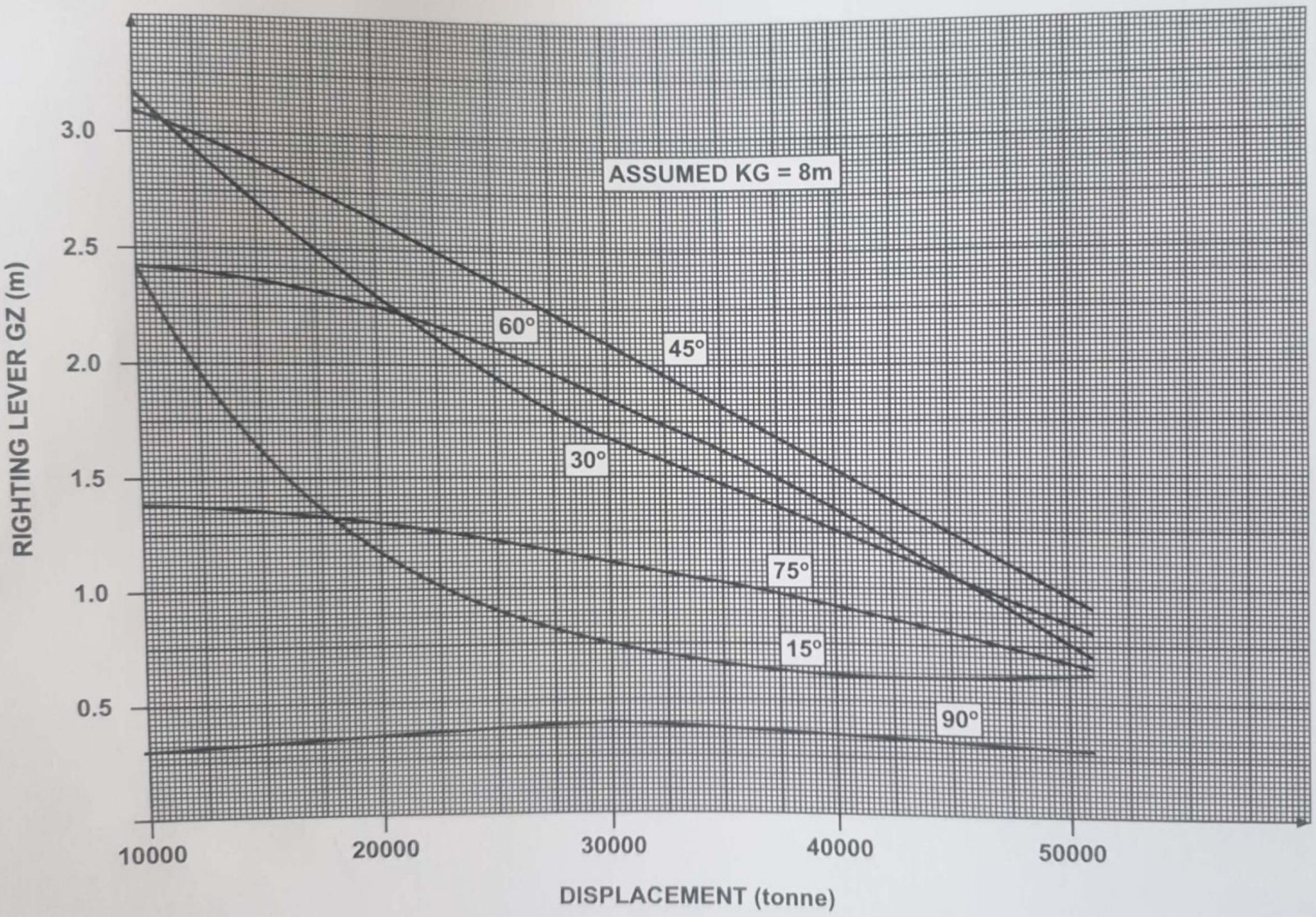
The following data in Table Q9 is available.

Draught (m)	Displacement (tonne)	LCB forward of midships (m)
6.0	10430	3.06
5.8	10000	3.08
5.6	9370	3.10
5.4	8590	3.12
5.2	7820	3.14
5.0	7230	3.16
4.8	6630	3.18
4.6	6040	3.20

Table Q9

(a) Plot a curve of moment of buoyancy about the aft end against a base of displacement. (10)

(b) Determine the upthrust exerted by the after blocks just before the ship touches the keel blocks all along its length. (6)



Candidate's Name .....

Examination Centre .....