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, 13 DECEMBER 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

Marks will not be awarded unless relevant working is CLEARLY shown

1. A ship 126 m long floats at a draught of 7.5 m and in this condition the immersed cross sectional areas and waterplane areas are as given in Tables Q1(A) and Q1(B). The *equivalent base area* (A_b) is required because of the fineness of the bottom shell.

Section	AP	1	2	3	4	5	FP
Immersed cross section area (m^2)	20	55	110	130	120	85	0

Table Q1(A)

Draught (m)	0	0.75	1.5	3.0	4.5	6.0	7.5
Waterplane area (m^2)	A_b	1000	1240	1510	1600	1680	1720

Table Q1(B)

Calculate EACH of the following:

(a) the equivalent base area value A_b; (8)

(b) the longitudinal position of the centre of buoyancy from midships; (4)

(c) the vertical position of the centre of buoyancy above the base. (4)

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2. A ship of 25420 tonne displacement floating in sea water has 800 tonne of bunker fuel of density 895 kg/m^3 in double bottom tanks which are pressed up full. In this condition the metacentric height is 0.25 m and the ordinates of the statical stability curve corresponding to this displacement are as shown in Table Q2.

Angle of heel (degrees)	0	5	10	15	20
GZ (metres)	0	0.012	0.050	0.098	0.160

Table Q2

The oil is transferred to a deep tank 4.85 m long by 18.2 m wide, situated on the ship's centreline. The centre of gravity of the fuel after transfer is 6.8 m above the original centre of gravity of the oil.

Determine EACH of the following for the new condition:

(a) the final effective metacentric height; (5)

(b) the angle to which the ship lists; (7)

(c) the dynamical stability at 20° angle of heel. (4)

3. The following particulars relate to a ship of length 220 m and breadth 36 m when fully loaded to an even keel draught of 12.4 m in sea water of density 1025 kg/m^3.

Displacement = 85000 tonne
waterplane area coefficient (C_w) = 0.82
longitudinal centre of flotation from midships (LCF) = 2 m aft
longitudinal metacentric height (GM_L) = 242 m

The ship may be considered to be wall sided in the region of the waterline.

Prior to the final loading operation, the draughts are 12.65 m aft and 11.00 m forward and the following two holds are available for the remaining cargo to be loaded:

No. 1 hold with lcg 60 m forward of midships
No. 4 hold with lcg 35 m aft of midships

Calculate the masses of cargo to be loaded into the two holds to bring the ship to its fully loaded even keel draught. (16)

4. A ship of displacement 6000 tonne in sea water of density of 1025 kg/m^3 has a breadth of 20 m and a draught of 5.5 m.

The area of waterplane is 1500 m^2, KB is 3.2 m, KG is 4.8 m and the second moment of area of the waterplane about the centreline is 22000 m^4.

A rectangular wing tank of length 10 m and breadth 4 m is situated above a double bottom of depth 1.1 m as shown in Fig Q4.

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

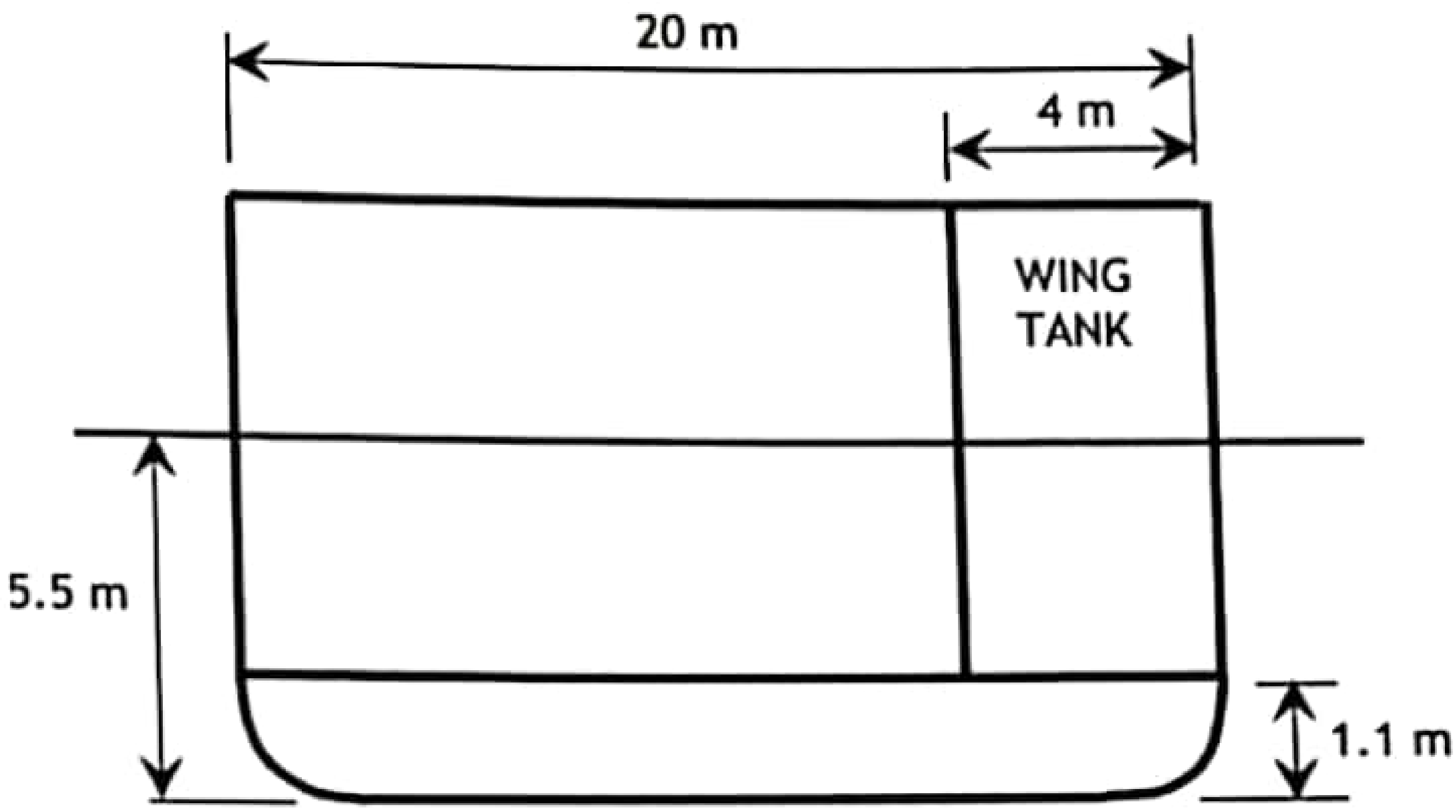

Fig Q4

5. A box barge of length 50 m is of uniform construction and has a displacement of 600 tonne when empty.

The barge is divided by four transverse bulkheads to form five holds of equal length. Cargo is loaded as shown in Fig Q5, the cargo in each hold being uniformly distributed.

No. 5 hold	No. 4 hold	No. 3 hold	No. 2 hold	No. 1 hold
400 tonne	300 tonne	400 tonne	500 tonne	300 tonne

AFT FORWARD

Fig Q5

For this condition of loading:

(a) verify that the barge has an even keel draught; (2)

(b) draw to scale EACH of the following:

(i) the load diagram; (6)

(ii) the shear force diagram; (5)

(c) using the diagrams drawn in Q5(b), determine the longitudinal position of the maximum bending moment. (3)

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6. (a) With the aid of a clearly labelled sketch, explain EACH of the following:

   (i) unbalanced rudder; (2)

   (ii) semi-balanced rudder; (2)

   (iii) balanced 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 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 rudder. (9)

7. A ship 137 m long displaces 13716 tonne. The shaft power required to maintain a speed of 15 knots is 4847 kW, and the propulsive coefficient based upon shaft power is 0.67.

$$wetted\ surface\ area = 2.58\sqrt{\Delta L}$$
$$propulsive\ coefficient = ep/sp$$

Values of the Froude friction coefficient for Froude's Formula are given in Fig Q7, with speed in m/s and speed index (n) = 1.825

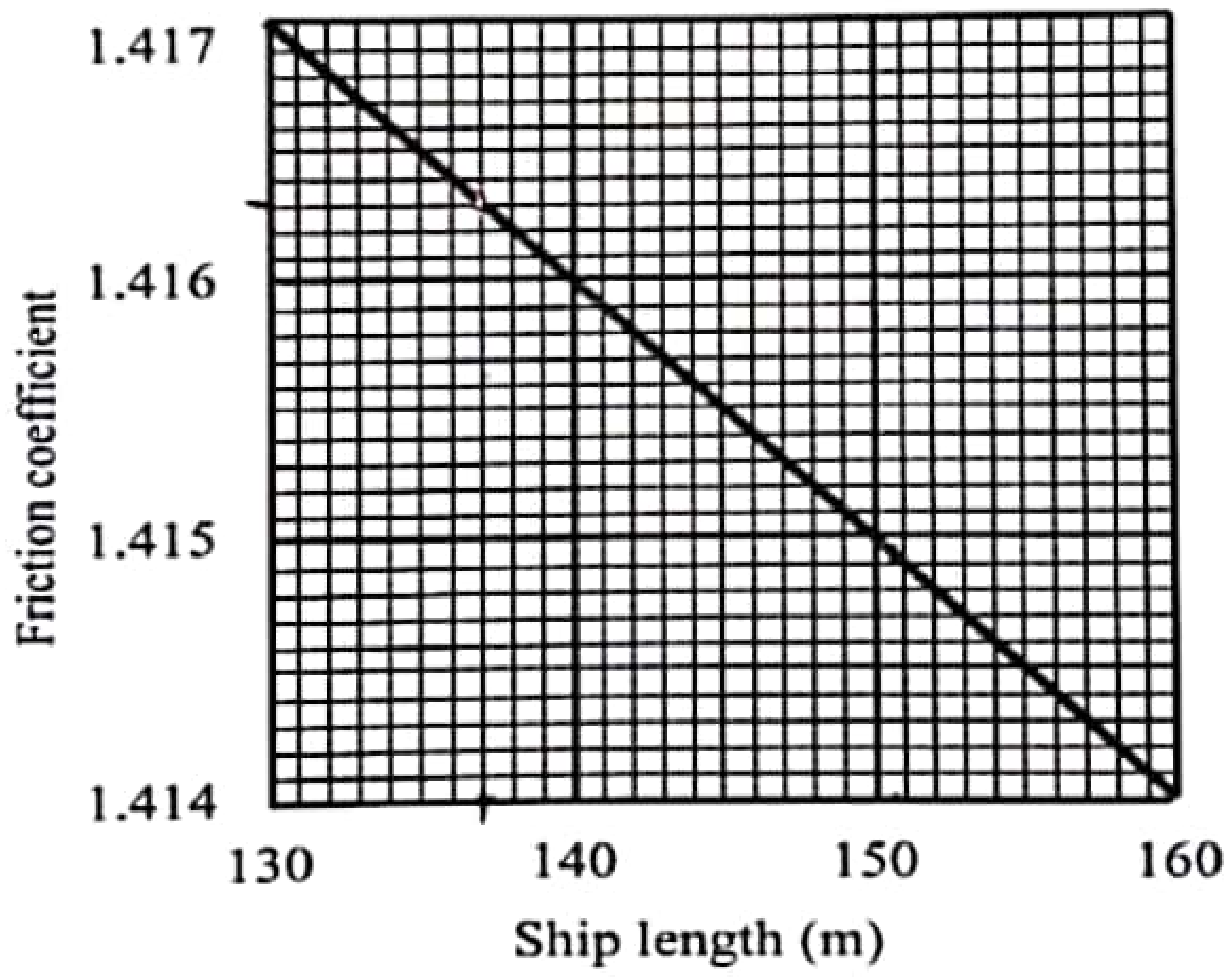

Fig Q7

Calculate the shaft power for a geometrically similar ship which has a displacement of 18288 tonne and which has the same propulsive coefficient as the smaller ship, and is run at the corresponding speed. (16)

8. The following data, shown in Table Q8, apply to a ship travelling at 17 knots:

propeller speed	1.85 revs/s
propeller pitch ratio	0.95
real slip ratio	0.34
Taylor wake fraction	0.30
torque delivered to the propeller	480 kNm
propeller thrust	640 kN
quasi-propulsive coefficient (QPC)	0.71
transmission losses	3%
fuel consumption per day	28 tonne

Table Q8

Calculate EACH of the following:

(a) the apparent slip ratio; (4)

(b) the propeller diameter; (2)

(c) the propeller efficiency; (4)

(d) the thrust deduction fraction; (4)

(e) the specific fuel consumption. (2)

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9 An end bulkhead of an upper hopper tank is shown in Fig Q9.

The tank is tested by filling with fresh water of density 1000 kg/m^3 through a filling pipe to a head of 2.5 m above the upper deck.

Calculate EACH of the following:

(a) the load on the bulkhead; (8)

(b) the distance to the centre of pressure from the upper deck. (8)

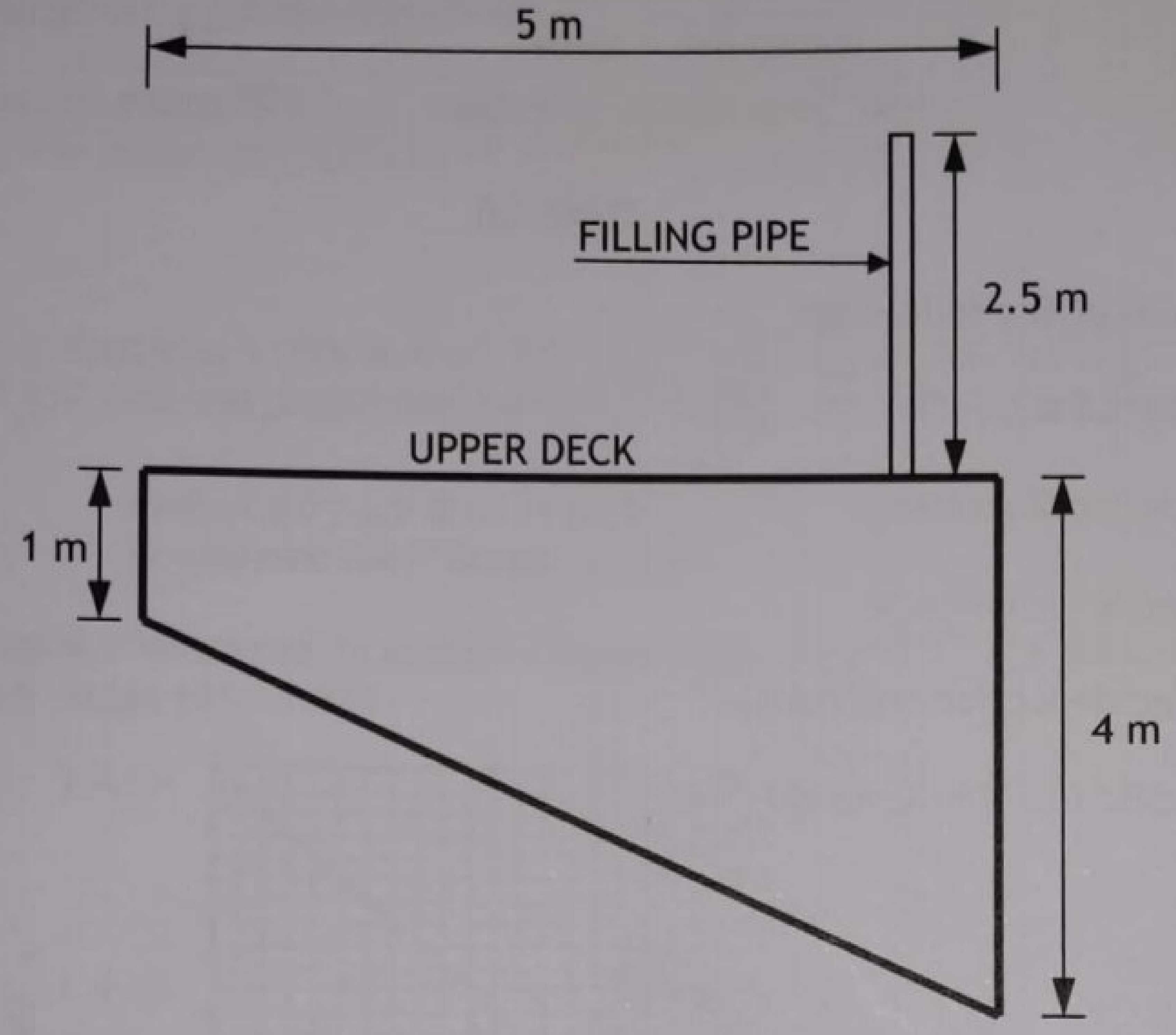

Fig Q9