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

040-34 - NAVAL ARCHITECTURE

FRIDAY, 15 DECEMBER 2017

0915 - 1215 hrs

Examination paper inserts:

Worksheet Q2

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:

NAVAL ARCHITECTURE

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

1. A ship's double bottom tank is divided by an oiltight centre girder to form equal port and starboard tanks. The tanks are 16 m long and have a constant plan area defined by equidistant ordinates from the centre girder to the sides of the ship of:

   6.0, 5.5, 4.8, 4.0 and 3.0 metres

   At a displacement of 12000 tonne in sea water of density 1025 kg/m³, the centre of gravity is 5.8 m above the keel and both tanks are partially full of oil of density 900 kg/m³ to a depth of 0.8 m.

   Calculate the change in effective metacentric height when all of the oil in both tanks has been consumed, assuming the position of the transverse metacentre to remain constant. (16)

2. A coastal tanker has a breadth of 15 m and in the lightship condition, has a displacement of 2450 tonne and a KG of 3.22 m.

   The vessel is now loaded as indicated in Table Q2.

Item	Mass (tonne)	Kg (m)
Crude oil Cargo	5600	4.85
Oil Fuel	300	2.59
Fresh Water	110	2.10
Stores etc.	40	8.30

Table Q2

   The following tanks are partially full with liquid as indicated.

   One rectangular tank 10 m long and 8 m wide, containing fuel oil of density 897 kg/m³.

   Four full width rectangular tanks, carrying crude oil of density 958 kg/m³, each 20 m long with centreline oiltight bulkheads.

   In this condition, when floating in sea water of density 1025 kg/m³ the height of the transverse metacentre above the keel (KM) is 5.235 m.

   (a) Calculate the effective metacentric height in the loaded condition. (8)

   (b) (i) Using Worksheet Q2, draw the curve of statical stability for the loaded condition. (7)

   (ii) From the curve drawn in Q2(b)(i), determine the range of stability. (1)

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3. The following particulars apply to a ship of length 140 m when floating in sea water of density 1025 kg/m^3 at an even keel draught of 7.265 m.

displacement	=	15800 tonne
centre of gravity above the keel (KG)	=	7.8 m
centre of buoyancy above the keel (KB)	=	4.05 m
waterplane area	=	2146 m^2
centre of flotation from midships (LCF)	=	3.0 m aft
second moment of area of the waterplane about a transverse axis through midships	=	2.305×10^6 m^4.

(a) Calculate the value of the moment to change trim by one centimetre (MCT 1 cm) in the above condition. (6)

(b) The ship in the above condition now undergoes the following changes in loading:

352 tonne added at an Lcg of 10.5 m forward of midships
110 tonne removed from an Lcg of 2.0 m aft of midships
150 tonne restowed at a new position 52.7 m aft of its original position.

Calculate the new end draughts of the ship. (10)

4. A ship of 7200 tonne displacement floats at a draught of 5.2 m in sea water of density 1025 kg/m^3. Area of waterplane is 1600 m^2, centre of buoyancy above the keel (KB) is 2.7 m and metacentric radius (BM) is 4.4 m.

A centrally located rectangular midship compartment 25 m long and 10 m wide is now bilged, causing bodily sinkage to a new draught of 5.8 m.

Calculate EACH of the following using the lost buoyancy method:

(a) the permeability of the compartment; (4)

(b) the change in transverse metacentric height due to bilging the compartment. (12)

5. The hull of a box shaped vessel is 80 m long and has a mass of 640 tonne uniformly distributed over its length. Machinery of mass 200 tonne extends uniformly over the middle 20 m length of the vessel.

Two holds extending over the extreme forward and aft 20 m lengths of the vessel each have 340 tonne of cargo stowed uniformly over their lengths.

(a) Construct curves of EACH of the following:

(i) load per metre; (8)

(ii) shearing force. (4)

(b) Calculate the value of the maximum bending moment. (4)

6. A spade-type rudder has an area of 6.89 m^2.

At its maximum designed rudder angle of 35°, the centre of effort is 0.125 m aft of the axis of rotation and 1.75 m below the lower edge of the rudder stock bearing.

The force on the rudder normal to the plane of the rudder is given by the expression:
$F_n = 18\ A\ v^2\ \alpha$ newtons

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

The equivalent twisting moment (T_E) is given by: $T_E = M + \sqrt{M^2 + T^2}$

where : M = bending moment
T = torque

The maximum stress in the rudder material is to be limited to 77 MN/m^2.

Calculate EACH of the following:

(a) the diameter of the rudder stock required for a ship speed of 17 knots; (8)

(b) the speed to which the ship must be restricted, given that the effective diameter of the stock is reduced by wear and corrosion to 410 mm. (8)

7. A ship of length 140 m and breadth of 22 m floats at a draught of 9 m in sea water of density 1025 kg/m^3. In this condition the block coefficient (C_b) is 0.72.

A geometrically similar model, 5 m in length, gives a total resistance of 30.85 N when tested at a speed of 1.55 m/s in fresh water of 1000 kg/m^3 at a temperature of 12°C.

The following data are also available:

Ship correlation factor 1.22
Temperature correction ±0.43% per °C
Frictional coefficient for the model in water of density 1000 kg/m^3 at 15°C is 1.694
Frictional coefficient for the ship in water of density 1025 kg/m^3 at 15°C is 1.415
Speed in m/s with index (n) for ship and model 1.825
Wetted surface area (S) = $2.57\sqrt{\Delta L}\ m^2$.

Calculate the effective power of the ship at the speed corresponding to the model when the ship is travelling in sea water of density 1025 kg/m^3 at a temperature of 15°C. (16)

8. (a) Explain the term *thrust deduction* with respect to a ship's propeller. (3)

(b) The following data were obtained during a ship's acceptance trials:

ship speed	=	15.6 knots
delivered power	=	2600 kW
effective power	=	1750 kW
thrust	=	280 kN
propeller efficiency	=	65%
apparent slip	=	6%

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) Show that when a ship is grounded on its centreline during docking, the transverse stability of the ship reduces by: $\frac{P \times KM}{\Delta}$

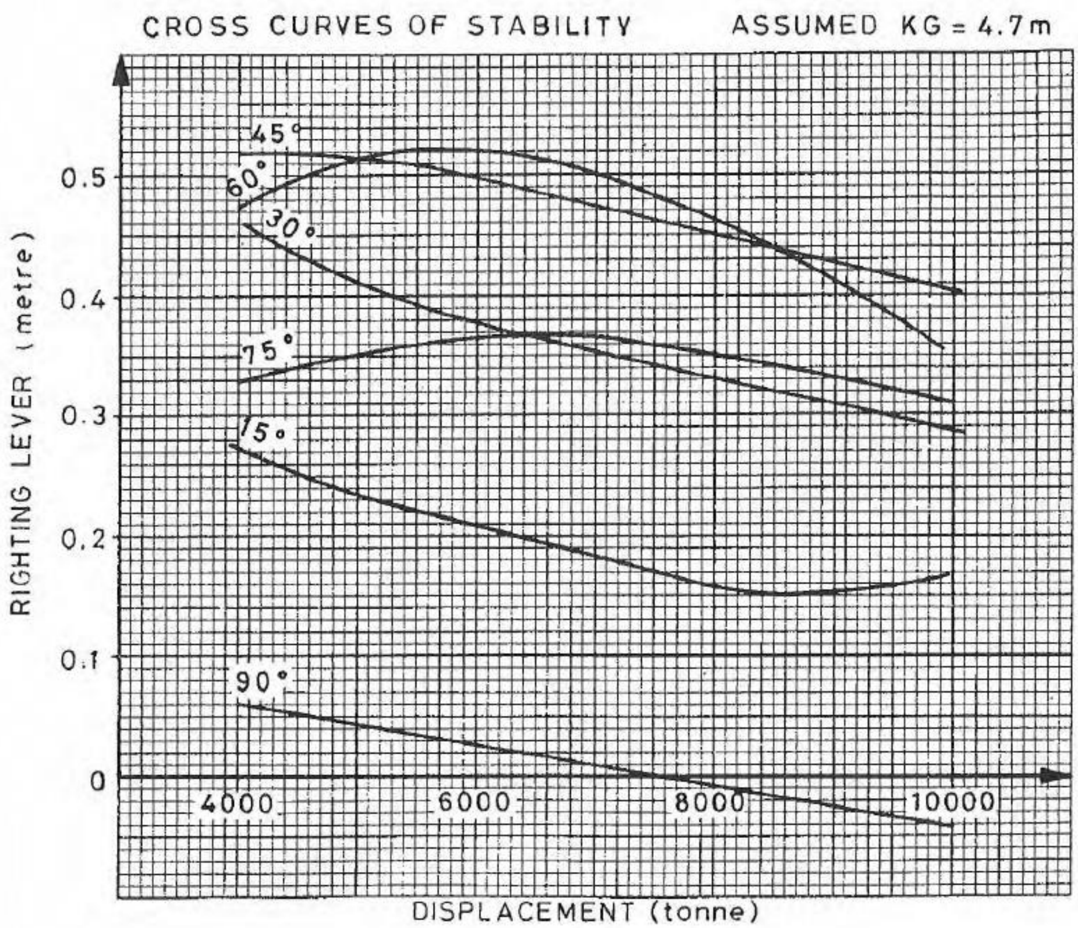
Where: Δ is the displacement
KM is the distance from keel to metacentre
P is the upthrust at the point of grounding. (8)

(b) A vessel 120 m long and 10000 tonne displacement enters dock with draughts 7.6 m aft and 6.7 m forward. KM = 8 m and KG = 7.6 m.

MCT 1cm = 110 tm and LCF is at midships.

Calculate the GM at the instant the ship grounds on the blocks. (8)

(This Worksheet must be returned with your answer book)



Candidate's Name .... Examination Centre ....