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 25 JULY 2014

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:

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 vessel of 10000 tonne displacement floats in sea water of density 1025 kg/m^3.

   A wing deep tank on the vessel is 16 m long, 8 m deep and has a constant plan area formed by the transverse end bulkheads and a longitudinal bulkhead, parallel to and 4 m from the centreline of the ship.

   The equally spaced transverse ordinates defining the plan area are as follows:

   4.00, 3.80, 3.50, 3.00 and 2.50 metres.

   The base of the tank is 2.0 m above the keel.

   With the deep tank full of oil of density 900 kg/m^3, the ship floats upright with a metacentric height of 0.725 m.

   Half of the oil in the deep tank is now removed.

   Calculate EACH of the following, assuming the KM remains constant at 5.125 m:

   (a) the final effective metacentric height; (14)

   (b) the final angle of heel. (2)

2. A coastal tanker has a breadth of 16 m and in the lightship condition, has a displacement of 2600 tonne and a KG of 3.34 m.

The vessel is now loaded as indicated in Table Q2.

Item	**mass (tonne)**	**KG (m)**
Crude oil Cargo	5900	4.65
Oil Fuel	330	2.60
Fresh Water	120	1.80
Stores etc.	50	8.90

Table Q2

The following tanks are partially full with liquid as follows:

One rectangular slop tank 10 m long and 8 m wide, containing fresh water of density 1000 kg/m^3 with oil of density 900 kg/m^3 floating on top;

Four full width rectangular tanks, carrying crude oil of density 952 kg/m^3, each 20 m long with centreline oiltight bulkheads.

In this condition, when floating in sea water of density 1025 kg/m^3 the height of the transverse metacentre above the keel (KM) is 5.286 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)

3. A ship of 125 m length has the following particulars when floating in sea water density 1025 kg/m^3.

displacement	=	11923 tonne
draught aft	=	7.244 m
draught forward	=	6.844 m
longitudinal metacentric height (GM_L)	=	130 m
longitudinal centre of flotation (LCF)	=	2.5 m aft of midships
tonne per centimetre immersion (TPC)	=	18.5

Two tanks, each containing a substantial quantity of water ballast, are situated with their centres of gravity 25 m aft of midships and 50 m forward of midships respectively.

The vessel is required to enter dock with a draught aft of 7.0 m and a trim of 0.6 m by the stern.

Calculate the mass of ballast to be removed from EACH tank. (16)

4. The force acting normal to the plane of a 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 angle (degrees)

A manoeuvrability specification for a ship that requires a transverse rudder force of 92 kN is generated when the angle of helm is 35° with the ship travelling at 5 knots.

(a) Determine suitable dimensions for a rectangular rudder having an aspect ratio (depth to width ratio) of 1.5. (6)

(b) The rudder stock is designed to have a diameter of 360 mm with the allowable shear stress in the material limited to 70 MN/m^2 at its service speed of 16 knots.

At the maximum helm angle of 35°, the centre of effort is 35% of the rudder width from the leading edge of the rudder.

Calculate the maximum distance of the axis of rotation from the leading edge of the rudder so that the stock is not overstressed at the service speed. (10)

5. A ship 140 m long has a load displacement of 21750 tonne in sea water of density 1025 kg/m^3. To maintain a speed of 16.5 knots in the above condition on trials, a shaft power of 7800 kW is required.

SCF for trial condition	=	1.08
SCF for service condition	=	1.24
Quasi-propulsive coefficient (QPC)	=	0.69
Transmission losses	=	3%
Wetted surface area (m^2)	=	$2.57\sqrt{\Delta L}$

Using the information given above, calculate the shaft power required in service for a geometrically similar ship of 26750 tonne load displacement operating at the corresponding speed. (16)

Note: *The frictional coefficient for the 21750 tonne ship in sea water is 1.415*
The frictional coefficient for the 26750 tonne ship in sea water is 1.413
speed is in m/s with index (n) = 1.825

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6. A ship of 25120 tonne displacement has a length of 140 m, breadth of 25 m and floats at a draught of 10 m when in sea water of density 1025 kg/m^3.

The ship's propeller has a diameter of 6 m with a pitch ratio of 0.85. When the propeller is operating at 1.85 rev/s, the real slip is 32% and the thrust power is 6200 kW.

The thrust power is reduced to 5000 kW and the real slip is increased to 34%.

Assuming that the thrust power is proportional to (speed of advance)^3 , calculate EACH of the following for the reduced power:

(a) ship speed; (11)

(b) the propeller speed of rotation; (3)

(c) the apparent slip. (2)

Note: Wake fraction = 0.5 C_b *- 0.05*

7. (a) Describe how the variable wake in which a propeller works may lead to vibration problems at the aft end. (4)

(b) Explain how a highly skewed propeller can reduce the problem of propeller excited vibration. (4)

(c) Discuss the validity of the following statement:

"The propeller design parameters that maximise efficiency will tend to lead to vibration problems" (4)

(d) Describe how the after end structure is constructed to resist vibration (4)

8. (a) Describe EACH of the following liquefied gas cargoes:

(i) liquefied natural gas (LNG); (2)

(ii) liquefied petroleum gas (LPG). (2)

(b) Explain how the physical properties of boiling point and critical temperature govern the containment system used for the transportation of the cargoes in Q8(a). (4)

(c) Describe, with the aid of a sketch, an independent tank system for the carriage of LNG. (8)

9. With respect to the Load Line rules:

(c) define EACH of the following terms:

(i) Freeboard; (2)

(ii) Freeboard deck; (2)

(iii) superstructure; (2)

(iv) type 'A' ship; (1)

(v) type ‘B’ ship. (1)

(b) Sketch and explain a set of freeboard marking for a vessel of length greater than 100 m. (8)