**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/m^3, the centre of gravity is 5.8 m above the keel and both tanks are partially full of oil of density 900 kg/m^3 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/m^3.

   Four full width rectangular tanks, carrying crude oil of density 958 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 5.235 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)

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)

SCOTTISH QUALIFICATIONS AUTHORITY
MARKERS REPORT FORM

SUBJECT: 040-34 Naval Architecture

DATE: 15th December 2017

General Comments on Examination Paper

Comments of Specific Examination Questions

Q1 (Simpsons Rule with transverse stability) An unpopular and poorly answered question.

Q2 (Large angle stability) Fairly well answered by many of the 14 candidates who attempted it.

Q3 (Small mass trim) Generally well answered but a number of candidates used the ship mass moment as the trimming moment.

Q4 (Bilging) As usual some candidates mixed added mass and lost buoyancy methods. Generally a poorly answered question.

Q5 (Load and SF curves) Generally well answered, but once again a number of candidates sketched the curves in their answer booklet instead of plotting the curves accurately on the supplied graph paper.

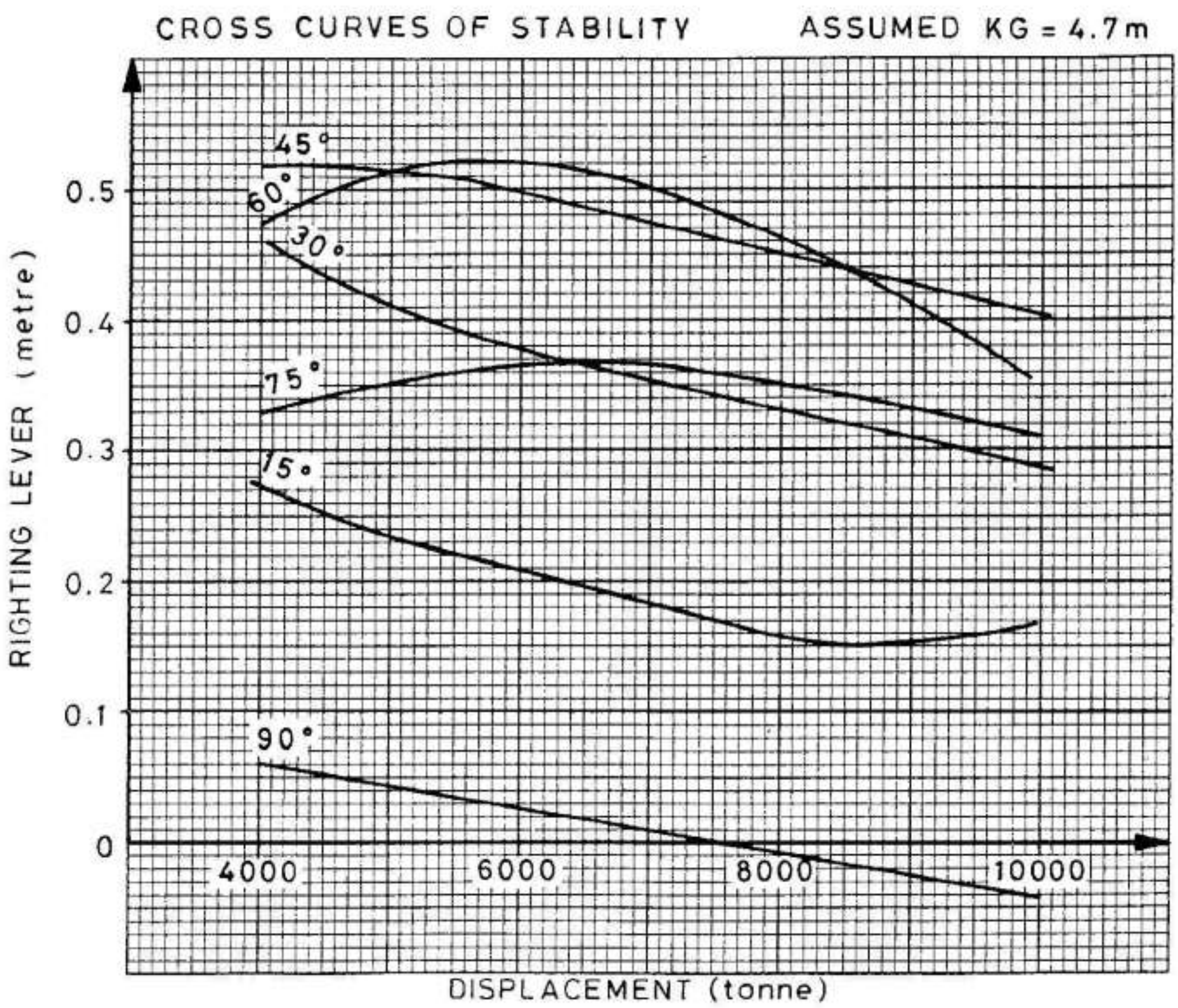
Q6 (Rudders) Very popular and very well answered.

Q7 (Resistance) Very popular and very well answered.

Q8 (Propellers and powering) Very popular and very well answered.

Q9 (Docking stability) This was the first question on this topic (which was not previously in the Chiefs Syllabus) and no candidate could successfully answer it. However, the volume of work required and the degree of difficulty should be well within the candidates ability. It would be expected that future candidates will have more success when this type of question becomes more commonplace.

(This Worksheet must be returned with your answer book)



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

CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY
MARINE ENGINEER OFFICER

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

041-34 – NAVAL ARCHITECTURE

FRIDAY, 31 MARCH 2017

0915 - 1215 hrs

Examination paper inserts:

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 ship of length 120 m displaces 11750 tonne when floating in sea water of density 1025 kg/m^3. The centre of gravity is 2.5 m above the centre of buoyancy and the waterplane is defined by the following equidistant half breadths given in Table Q1:

Station	AP	1	2	3	4	5	6	7	FP
Half-breadth (m)	3.3	6.8	7.6	8.1	8.1	8.0	6.6	2.8	0

Table Q1

Calculate EACH of the following:

(a) the area of the waterplane; (3)

(b) the position of the centroid of the waterplane from midships; (3)

(c) the second moment of area of the waterplane about a transverse axis through the centroid; (5)

(d) the moment to change trim one centimetre (MCT 1cm). (5)

2. A vessel has a depth of 10 m and a displacement of 8000 tonne when the metacentric height is 1.2 m and height to the metacentre (KM) is 7.4 m.

Two adjacent rectangular bunkers, extending over the full depth of the vessel, each 10 m long and 6 m wide, are situated either side of the centreline.

Each bunker is full of fuel oil of density 900 kg/m^3.

Fuel is consumed from one bunker until a maximum angle of list of 3° is caused.

Calculate the maximum mass of fuel initially consumed before switching to the other bunker. (16)

Note: KM can be assumed constant.

3. A vessel of constant rectangular section 80 m long and 12 m wide had a KG of 4.77 m and floats on an even keel draught of 5.5 m in water of density 1025 kg/m^3. The vessel is fitted with a transverse watertight bulkhead 10 m from the forward end.

The compartment forward of the transverse bulkhead, which has a permeability of 60%, is now damaged and laid open to the sea.

Calculate the new end draughts of the vessel. (16)

4. A box barge of length 40 m is of uniform construction and has a displacement of 800 tonne when empty.

The barge is divided by three transverse bulkheads to form four holds of equal length.

Cargo is loaded as shown in Fig Q4, the cargo in each hold being uniformly distributed.

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; (4)

(c) determine the longitudinal position and value of the maximum bending moment, stating whether it is hogging or sagging. (4)

No.4 hold 600 tonne	No.3 hold 200 tonne	No.2 hold 800 tonne	No.1 hold 400 tonne

AFT FORWARD

Fig Q4

5. A ship model of length 6 m has a wetted surface area of 6.62 m^2.

When tested in fresh water of density 1000 kg/m^3, at a speed of 1.8 m/s, the total resistance was measured at 48 N.

This tank speed corresponds with a trial ship speed of 17.5 knots in sea water of density 1025 kg/m^3, which is achieved when the shaft power is 8720 kW, when the propulsive coefficient is 0.67.

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 1.655
The frictional coefficient for the ship in sea water is 1.413
Speed in m/s with the speed index (n) for ship and model 1.825.

6. The following data were obtained during acceptance trials for a ship of 11650 tonne displacement:

ship speed 16 knots
torque delivered to the propeller 340 kNm
propeller thrust 465 kN
propeller speed 1.85 rev/s
effective power 2900 kW
propeller efficiency 67%
apparent slip ratio 0.06
transmission losses 3%

Calculate EACH of the following:

(a) the pitch of the propeller; (3)
(b) the Taylor wake fraction; (4)
(c) the real slip ratio; (1)
(d) the thrust deduction fraction; (3)
(e) the quasi-propulsive coefficient; (2)
(f) the Admiralty Coefficient based upon shaft power. (3)

7. (a) Explain how a propeller blade may be eroded due to cavitation, describing the progressive nature of the damage. (8)

(b) Outline the design features that may be considered to minimise cavitation. (8)

8. (a) State the THREE basic principles of fire protection of a ship. (6)

(b) Describe the fire protection requirements for stairways and lifts. (5)

(c) Describe a fire door suitable for an 'A-60' class bulkhead. (5)

9 (a) Sketch a modern oil tanker midship section of double hull construction. (8)

(b) Describe the advantages and disadvantages of this type of construction. (8)

SCOTTISH QUALIFICATIONS AUTHORITY
MARKERS REPORT FORM

SUBJECT: 041-34 Naval Architecture

DATE: 31st March 2017

General Comments on Examination Paper
An average mark of 54.6 /96 (56.9%)

Comments of Specific Examination Questions

Q1 Simpsons Rule with area, centroid, $I_{MIDSHIPS}$ and MCT1cm– many candidates wrongly calculated the moment and second moment using ordinates squared and cubed ($I_{CENTRELINE}$ calculation)

Q2 As usual stability not popular and only done well by a small number of candidates

Q3 Bilging and trim also not a popular subject but generally done well by the small number of candidates who attempted it. A few candidates still mix added mass and lost buoyancy methods, the most common error is calculating added mass to the original waterline.

Q4 Many candidates are still sketching load and shear force curves in their answer booklets instead of plotting accurately on graph paper.

Q5 Resistance – very popular and very well answered

Q6 Propellers and powering – very popular and very well answered. However, a large number of candidates used incorrect units to calculate Admiralty Coefficient

Q7 Standard cavitation question that has appeared in many previous exams - still not well answered.

Q8 Fire protection – poorly answered with many candidates describing the fire triangle for (a) instead of the 3 principles of construction – zones, fire detection and fighting, means of escape.

Q9 Double hull tanker – fairly well answered

Confidential Comments

CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY – MARINE ENGINEER OFFICER

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

041-34 – NAVAL ARCHITECTURE

FRIDAY, 16 DECEMBER 2016

0915 - 1215 hrs

Examination paper inserts:

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 ship 160 m in length has a load displacement of 20500 tonne and floats in water of density 1025 kg/m^3. The load waterplane is defined by equally spaced half breadths as shown in Table Q1.

Section	AP	1	2	3	4	5	6	7	FP
Half-breadth (m)	1	6	10	11	12	11	9	5	0

Table Q1

The following particulars are also available:

centre of buoyancy above the keel (KB) 4.264 m
centre of gravity above the keel (KG) 7.561 m
centre of lateral resistance above the keel 4.050 m

A rectangular tank, partially filled with oil of relative density 0.89 has overall dimensions of 10 m by 10 m, but it is divided into two equal tanks by an oiltight longitudinal bulkhead.

Calculate EACH of the following:

(a) the effective metacentric height; (12)

(b) the angle to which the ship will heel when turning on a circular course of 400 m diameter at a speed of 16 knots. (4)

[OVER

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 follows:

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

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 that the ship heels to; (7)

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

5. 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 Q5, with speed in m/s and speed index (n) = 1.825.

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

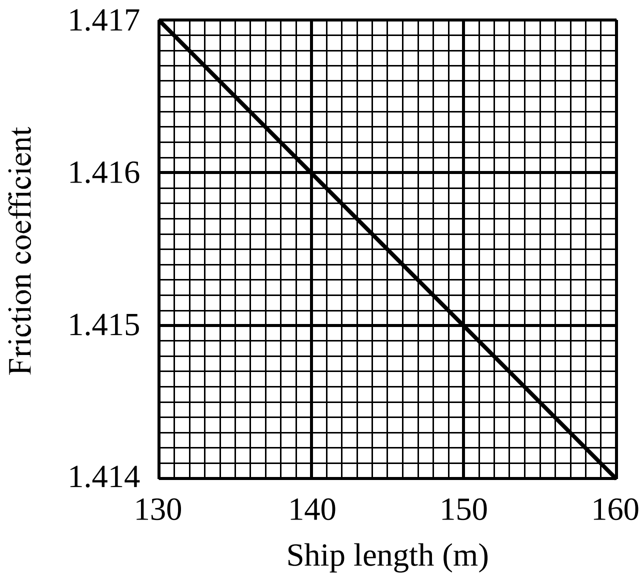

Fig Q5

6. The following data applies to a ship operating on a particular voyage with a propeller of 6 m diameter having a pitch ratio of 0.9:

propeller speed	1.85 revs/s
real slip	33%
apparent slip	6%
shaft power	11000 kW
specific fuel consumption	0.205 kg/kW hr

Calculate EACH of the following:

(a) the ship speed; (3)

(b) the Taylor wake fraction; (3)

(c) the reduced speed at which the ship should travel in order to reduce the voyage consumption by 30%; (2)

(d) the voyage distance if the voyage takes 30 hours longer at the reduced speed; (4)

(e) the amount of fuel required for the voyage at the reduced speed. (4)

7. (a) Explain the circumstances under which whipping stresses may occur in ships. (4)

(b) Describe the use of stress indicators on board a ship. (4)

(c) Sketch a graph of stress versus time indicating whipping. (2)

(d) Describe the structure on a ship that would resist whipping. (6)

8. (a) State the FOUR cargo systems that may be used for the carriage of liquefied gases. (4)

(b) (i) Describe, with the aid of a sketch, a membrane tank containment system suitable for the carriage of liquefied natural gas (LNG). (8)

(ii) Sketch the barrier and insulation system for the membrane tank described in Q8(b)(i). (4)

9. (a) Explain, with the aid of an outline sketch, 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, with the aid of a sketch, 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 the rudder. (9)

SCOTTISH QUALIFICATIONS AUTHORITY
MARKERS REPORT FORM

SUBJECT: 041-34 Naval Architecture

DATE: 16th Dec 2016

General Comments on Examination Paper

An average mark of 58.7/96 (61.1%)

Most candidates answered the calculation questions (Q1 to 6) very well.

The descriptive questions (Q7, 8 and 9) were answered fairly well compared to previous exams.

All questions had an average mark greater than 50%

Comments of Specific Examination Questions

Q1 Simpsons Rule with angle of heel when turning required an $I_{CENTRELINE}$ calculation – many candidates wrongly calculated I_F

Q5 A number of candidates re-plotted the graph given in the question paper from which they simply had to pick up two values.

Q6(c) required simply one line – Voyage consumption proportional to V^2
Many candidates incorrectly used V^3 or used a long calculation to arrive at an incorrect answer.

Q8 A number of candidates sketched and described an independent tank instead of the required membrane tank

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

041-34 – NAVAL ARCHITECTURE

FRIDAY, 21 OCTOBER 2016

0915 - 1215 hrs

Examination paper inserts:

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.

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 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).

   A_b is the waterplane area at the base.

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 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)

2. The *wall sided formula* gives an expression for righting lever (GZ) as follows:

$$GZ = \sin\theta\,(GM + \tfrac{1}{2}BM \tan^2\theta)$$

(a) Derive an expression for the *angle of loll* of a ship which is initially unstable in still water, using the wall sided formula. (5)

(b) A box shaped vessel is 60 m long, 12 m wide and floats at a draught of 5 m in sea water of density 1025 kg/m^3 with a KG of 4.826 m.
A beam wind acts on the exposed area of the vessel causing it to heel to an angle of 15°.

The heeling moment caused by the wind is given by the expression:
Heeling moment = $0.85\ A\ b\ v^2 \cos^2\theta$ Nm

where: A = exposed area = 360 m^2
b = lever = 5.5 m
v = wind speed in m/s
θ = angle of heel in degrees.

Calculate the wind speed using the wall sided formula for GZ. (11)

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 moment to change trim by one centimetre (MCT 1 cm). (4)

(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 EACH of the following for the new condition:

(i) the new end draughts of the ship; (9)

(ii) the longitudinal position at which a mass of 204 tonne should be added to restore the ship to an even keel draught. (3)

4. A box shaped barge of uniform construction is 66 m long and 10 m wide. The barge is divided into three compartments by two transverse watertight bulkheads to form a central compartment and two equal length end compartments.

The barge is loaded with bulk cargo, evenly distributed over the full length of the barge, the resulting permeability of the barge being 60%. The barge floats in river water of density 1008 kg/m^3 with an even keel draught of 5.0 m.

The midship compartment, extending the full width and depth of the barge, is now bilged and the draught increases to 5.5 m.

(a) Determine the length of the midship compartment. (4)

(b) For the final condition:

(i) draw curves of mass and buoyancy distribution; (8)

(ii) determine the longitudinal still water bending moment at midships, stating whether it is hogging or sagging. (4)

5. Fig Q5 shows the results of progressive speed trials on a ship at a load displacement of 22350 tonne in sea water of density 1025 kg/m^3 with a wetted surface area of 4860 m^2.

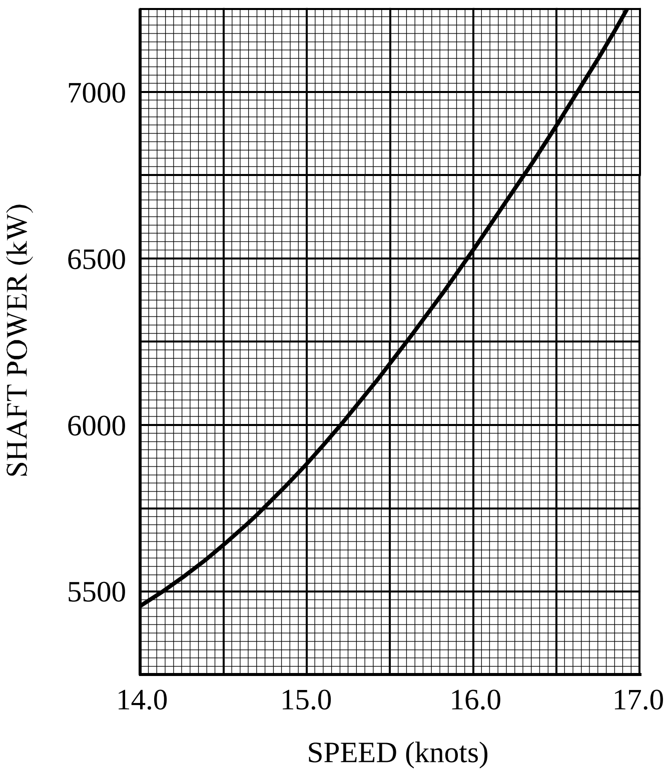

Fig Q5

Using the data given below, calculate the shaft power required to achieve a service speed of 17 knots with a geometrically similar ship having a load displacement of 29245 tonne in sea water. (16)

allowance for appendages and weather in trial condition	8%
allowance for appendages and weather in service condition	20%
propulsive coefficient based upon shaft power for trial and service conditions	0.68

The frictional coefficient for the 22350 tonne ship in sea water is 1.410
The frictional coefficient for the 29245 tonne ship in sea water is 1.406
When speed is in m/s with index (n) = 1.825

6. 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 rev/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)

7. (a) State FOUR disadvantages of mild steel as a material for ship construction. (4)

(b) Describe materials used as alternatives to mild steel, to overcome some of the disadvantages stated in Q7(a), stating examples of their possible application. (12)

8. (a) With reference to audible noise waves as received by the human ear varying in loudness:

(i) explain how the loudness of the noise varies with respect to a sound wave; (4)

(ii) explain the dB(A) units of noise measurement. (4)

(b) Describe, with the aid of a sketch, how a cabin may be designed to minimise the transmission of sound. (8)

9. (a) Sketch transverse cross sections of a ship, showing the forces acting when the ship is lying at a large angle of heel due to EACH of the following, indicating the positions of the initial and final centres of buoyancy and gravity and the initial position of the transverse metacentre:

(i) an external force (wind or wave); (2)

(ii) a transverse shift of cargo; (2)

(iii) initial instability. (2)

(b) Sketch and label typical statical stability curves for EACH of the following ship loading conditions:

(i) the ship's centre of gravity on the centreline and the ship having a positive metacentric height; (4)

(ii) the ship's centre of gravity off the centreline and the ship having a positive metacentric height; (3)

(iii) the ship's centre of gravity on the centreline and the ship having a negative metacentric height. (3)

SCOTTISH QUALIFICATIONS AUTHORITY
MARKERS REPORT FORM

SUBJECT: 041-34 Naval Architecture

DATE: 21st October 2016

General Comments on Examination Paper

Whilst there were the usual very good scripts there was an unusually high number of very poor scripts.

Comments of Specific Examination Questions

Q1,5&6 - 1(Simpsons Rule), 5 (Resistance) and 6 (Propellers, Powering & Fuel Consumption) were all popular and well answered. However in the calculation of Fuel Coefficient (Q6) many candidates incorrectly used speed in m/s when it should be in knots.

Q2 Stability with wall sided formula. Popular with 2 of the 4 examination centres, whist in the other 2 centres only 2 candidates from 24 answered the question (very well)

Q3 Trim – (a) answered well (b) & (c) answered poorly.
This type of question has been asked many times in the past with very few problems.

Q4 Part (a) was answered OK but (b) & (c) were very poorly answered. Rough sketches were used instead of plotting load curves on graph paper and no candidate correctly calculated the relatively simple load per metre (b) and bending moment midships (c). This type of question has been used a number of times in previous exams with better reults.

As usual the descriptive questions (Q7, 8 and 9) were less popular than the calculations, and generally not well answered

**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) CHIEF ENGINEER REG. III/2 (UNLIMITED)

041-34 – NAVAL ARCHITECTURE

FRIDAY, 15 JULY 2016

0915 - 1215 hrs

Examination paper inserts:

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 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 box shaped vessel is 100 m long, 20 m wide and floats at a draught of 5 m.

Due to a collision, a full width compartment 25 m long situated at midships, is bilged.

Calculate EACH of the following, using the *lost buoyancy* method:

(a) the permeability of the compartment if the final draught in the bilged condition is 5.85 m; (6)

(b) the change in transverse metacentric height due to bilging this compartment. (10)

[OVER

3. The following data 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 box barge of 88 m length, 12 m breadth and 6 m depth has a hull mass of 600 tonne evenly distributed throughout its length.

Bulkheads located 4 m from the barge ends, form peak tanks which may be used for ballast. The remainder of the barge length is divided by 4 transverse bulkheads into 5 holds of equal length. The holds are full of bulk cargo having a stowage rate of 1.6 m^3/t.

The peak tanks are empty.

(a) Calculate the midship bending moment during discharge when both end holds are half empty. (8)

(b) Calculate the minimum depth of sea water ballast of density 1025 kg/m^3, which must be added to the peak tanks to allow complete discharge of the end holds if the midship sagging bending moment is to be restricted to a maximum of 50 MNm. (8)

5. The following data in Table Q5 were obtained during progressive speed trials on a ship of 11400 tonne displacement.

Ship speed (knots)	12	13	14	15	16
Shaft power (kW)	1960	2455	3040	3720	4505

Table Q5

Under normal service conditions, the ship operates within this range and has an Admiralty Coefficient of 458, based upon shaft power.

(a) (i) Determine the normal service speed of the ship. (6)

(ii) In a fouled hull condition, with the service shaft power being maintained, the ship's speed is found to have decreased by 6% from normal. Assuming that the specific fuel consumption remains constant at 190 g/kWhr, determine the increase in fuel consumed over a distance of 2500 nautical miles. (5)

(b) A geometrically similar ship having a displacement of 13500 tonne is to be built.

Determine the shaft power required for this ship at a speed of 15.5 knots. (5)

6. The wetted surface area of a container ship is 7135 m^2.

When travelling at service speed, the shaft power required is 22500 kW with residuary resistance 25% of the total resistance and specific fuel consumption is 0.22 kg/kWhr.

Propulsive coefficient, based upon shaft power is 0.6.

Friction coefficient in sea water is 1.411 when speed is in m/s
Speed index (n) is 1.825.

(a) Calculate the service speed of the ship. (10)

(b) To conserve fuel the ship speed is reduced by 10%, the daily fuel consumption is then found to be 100 tonne.

The propulsive coefficient may be assumed constant at 0.6.

Calculate the percentage increase in specific fuel consumption when running at the reduced speed. (6)

7. (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)

8. State the problems associated with the carriage of EACH of the following products, describing the precautions necessary for the safe transportation of EACH:

(a) grain; (4)

(b) timber on deck; (4)

(c) iron ore; (4)

(d) concentrates (finely grained minerals) containing a proportion of moisture. (4)

9. With reference to the testing of a ship model in a towing tank:

(a) define the term *corresponding speed*; (2)

(b) state Froude's Law of Comparison; (2)

(c) explain how the effective power of a ship can be estimated from the model test. (12)

SCOTTISH QUALIFICATIONS AUTHORITY
MARKERS REPORT FORM

SUBJECT: 041-34 Naval Architecture

DATE: 15th July 2016

General Comments on Examination Paper

A low than usual average mark of 50.8/96 (52.9%)

Comments of Specific Examination Questions

Calculation questions 1, 2, 3, 5 and 6 were well answered.

Q4 Bending moment calculation was attempted by 21 of the 55 candidates of which about half answered the question very well whilst the other half answered the question poorly. This is bewildering since it is a regular type of question that has been asked many times in previous years with better results.

A number of candidates got into trouble by attempting to plot load, SF and BM diagrams when the question clearly stated calculate.

Q5 Admiralty Coefficient – clearly needed a graphical solution for part (a)(i) – a number of candidates used linear interpolation

As usual the descriptive questions (Q7, 8 and 9) were less popular than the calculations.

Q7 Propellers – generally not well answered

Q8 Problem cargoes – generally not well answered

Q9 Resistance – answered satisfactorily

CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY – MARINE ENGINEER OFFICER

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ON BEHALF OF THE
MARITIME AND COASTGUARD AGENCY

STCW 95 CHIEF ENGINEER REG. III/2 (UNLIMITED)

041-34 – NAVAL ARCHITECTURE

FRIDAY, 8 APRIL 2016

0915 - 1215 hrs

Examination paper inserts:

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 RO-RO ferry of length 120 m has a displacement of 12800 tonne in sea water of density 1025 kg/m^3 with BM = 4.6 m.

   The breadth of the ship at the waterline, between sections 3 and 7 is constant at 20 m.

   To increase stability, *sponsons*, 2.7 m deep and of constant plan area are to be fitted as shown in Fig Q1. For the new condition there is no change in draught and the load waterline is at mid-depth of the sponson.

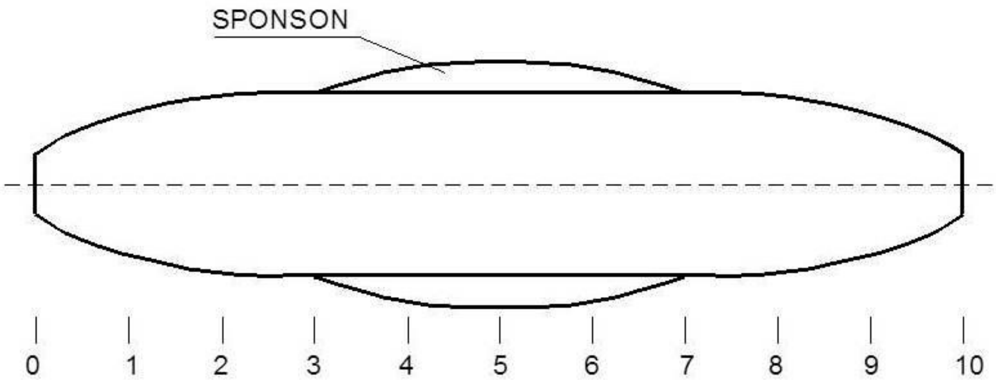

Fig Q1

The sponsons extend over the midship length between sections 3 and 7, with sponson widths as shown in Table Q1.

Section	3	4	5	6	7
Sponson width (m)	0	1.8	2.7	1.8	0

Table Q1

Calculate the increase in BM due to the sponsons. (16)

2. A ship of length 150 m and breadth 20 m floats upright at a draught of 7.5 m in sea water of density 1025 kg/m^3 and the height of the centre of gravity above the keel (KG) is 5.388 m.

Further hydrostatic data for this condition are as follows:

centre of buoyancy above the keel (KB)	=	3.956 m
height of metacentre above the keel (KM)	=	7.014 m
waterplane area coefficient (C_w)	=	0.82
block coefficient (C_b)	=	0.72

In the above condition there is an empty rectangular wing tank 16 m long, 5 m wide and 5 m deep, adjacent to the hull and directly above a double bottom tank 1.2 m deep.

Assuming the ship to be wall sided over the change of draught, calculate the angle to which the ship will heel when the tank is completely filled with fresh water of density 1000 kg/m^3. (16)

3. A ship of length 160 m has the following hydrostatic particulars when floating at an even keel draught in sea water of density 1025 kg/m^3.

waterplane area	=	1951 m^2
displacement	=	15058 tonne
longitudinal metacentric height (GM_L)	=	170 m
centre of flotation from midships (LCF)	=	1.5 m aft

The ship in the above condition grounds on a rock which may be assumed to be at a point 55 m forward of midships and settles such that the end draughts are 6.65 m aft and 5.52 m forward.

Calculate the original draught of the ship. (16)

4. 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) Draw 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)

5. A ship model of length 5 m has a wetted surface area of 4.2 m^2 and is tested in water of density 1000 kg/m^3. The test results give the values of residuary resistance for a range of model speeds as shown in Table Q5.

Model speed (m/s)	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80
Residuary resistance (N)	3.00	3.35	3.85	4.60	5.80	7.40	9.15	10.50	11.40

Table Q5

(a) (i) Plot a curve of residuary resistance against speed for the model. (2)

(ii) Comment on the shape of this curve. (2)

(b) For a geometrically similar ship of length 125 m operating in sea water of density 1025 kg/m^3 at service speed of 16.0 knots, the following data is applicable:

appendage allowance	=	7%
weather allowance	=	14%
quasi-propulsive coefficient (QPC)	=	0.7
transmission losses	=	3%

Determine the shaft power required for the ship at its service speed. (12)

Note: The frictional coefficient for the ship in sea water is 1.42 with speed in m/s and index(n) for ship and model is 1.825.

6. A ship 145 m long, 24.5 m beam, displaces 24910 tonne when floating at a draught of 9.5 m in sea water of density 1025 kg/m^3.

The propeller has a diameter of 6.0 m and a pitch ratio of 0.95.

With the propeller operating at 1.75 revs/sec, the following results were recorded:

propeller thrust	=	1300 kN
real slip	=	35%
propeller efficiency	=	67%
transmission losses	=	3%
fuel consumption per day	=	63 tonne

Calculate EACH of the following:

(a) the ship speed; (6)

(b) the apparent slip; (2)

(c) the specific fuel consumption; (4)

(d) the mass of fuel required to travel 3500 nautical miles at a speed of 17.5 knots including a reserve of 10%. (4)

Note: Wake fraction (W_T) = 0.5 C_b - 0.05

7. (a) Explain the term *composite material*. (3)

(b) Describe the composition of GRP, outlining its advantages for use on lifeboats. (7)

(c) Describe the disadvantages of GRP when compared to low carbon (mild) steel. (6)

8. With reference to the carriage by sea of hazardous chemicals in bulk:

(a) explain how the protection of the internal structure is achieved; (8)

(b) outline the safety precautions to be observed by crew members to ensure personal safety. (8)

9. With reference to the tonnage measurement of a ship:

(a) explain the difference between *Gross Tonnage* and *Net Tonnage*. (4)

(b) explain EACH of the following terms:

(i) enclosed spaces; (2)

(ii) excluded spaces. (4)

(c) State the functions of the *Tonnage Certificate*, giving examples of its use in the day-to-day operations of ships. (6)

SCOTTISH QUALIFICATIONS AUTHORITY
MARKERS REPORT FORM

SUBJECT: 041-34 Naval Architecture

DATE: 8th April 2016

... on Examination Paper

A low average mark of 56.1/96 (58.4%).

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Comments of Specific Examination Questions

Q2 (transverse stability), Q5 (resistance) and Q6 (propellers and powering) were all very popular and well answered.

Q4 (shear force and bending moment) was not as well answered as usual. Many candidates were simply sketching the curves instead of drawing them to scale on graph paper – which was provided.

Q8(b) (chemical carriers) A number of candidates did not answer the question asked.
They described chemical carrier types I, II and III and there layout to cope with 'reasonable damage' instead of describing the internal coating systems and material choices to protect against the chemical cargoes.

Confidential Comments

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, 18 December 2015

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 ship of length 180 m, floats at its load draught with a displacement of 50000 tonne in sea water of density 1025 kg/m^3. The longitudinal centre of buoyancy (LCB) is 1.80 m aft of midships.

   In this condition, the forward half of the ship displaces 23000 tonne and has a centre of displaced volume (lcb) 33.0 m forward of midships. This part of the ship is to be replaced with a new forward half of similar length, but having new immersed cross section areas, to the same load draught, as given in Table Q1.

Section	Midships	6	7	8	9	9½	FP
Section area (m^2)	370	354	330	272	172	95	0

Table Q1

   Calculate EACH of the following, for the new condition:

   (a) the displacement of the ship; (6)

   (b) the longitudinal position of the ship's centre of buoyancy. (10)

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) Using the cross curves of stability provided in Worksheet Q2, construct a curve of statical stability for the loaded vessel. (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 130 m is loaded as shown in Table Q3(a).

Item	Mass (tonne)	Lcg from midships (m)
lightship	3850	1.52 aft
cargo	8645	3.40 forward
oil fuel	860	7.25 aft
stores	35	15.20 forward
fresh water	90	26.80 forward
crew & effects	20	midships

Table Q3(a)

Table Q3(b) is an extract from the ship's hydrostatic particulars and linear interpolation may be used to obtain data at intermediate draughts.

Draught (m)	Displacement (tonne)	LCB from midships (m)	MCT 1cm (tm)	LCF from midships (m)
8.0	14600	2.1 forward	179	0.3 aft
7.0	12600	2.5 forward	167	0.5 forward

Table Q3(b)

Determine the end draughts of the ship after loading has been completed. (16)

[OVER

4. A single screw ship with a service speed of 16 knots is fitted with a rectangular rudder, 6.5 m deep and 4 m wide, with its axis of rotation 0.4 m from the leading edge.

At a rudder helm angle of 35 degrees, the centre of effort is 32% of the rudder width from the leading edge.

The force (F) on the rudder normal to the plane of the rudder is given by the expression:

$$F = 577\ A\ v^2 \sin \alpha \quad \text{(newtons)}$$

Where: A = area of the rudder (m^2)
v = ship speed (m/s)
α = rudder angle (degrees)

The maximum stress on the rudder stock is to be limited to 70 MN/m^2.

Calculate EACH of the following, for a rudder angle of 35 degrees:

(a) the minimum diameter of the rudder stock for ahead running; (9)

(b) the speed of the ship, when running astern, at which the maximum stress level would be reached. (7)

5. A ship of length 145 m and breadth 23 m floats at a draught of 10 m in sea water of density 1025 kg/m^3 with a block coefficient of 0.72.

A geometrically similar model 5 m in length, when tested at a speed of 1.48 m/s in fresh water of density 1000 kg/m^3 gives a total resistance of 29.25 N.

Using the data given below, determine the service delivered power for the ship at the corresponding speed to that of the model. (16)

allowance for appendages	=	5%
allowance for weather	=	16%
quasi-propulsive coefficient (QPC)	=	0.71

The frictional coefficient for the model in fresh water is 1.694
The frictional coefficient for the ship in sea water is 1.414
When speed is in m/s with index (n) = 1.825
Wetted surface area (m^2) = 2.57 $\sqrt{\Delta \times L}$.

6. A ship 156 m in length, 22 m breadth, displaces 19700 tonne when floating at a draught of 8 m in sea water of density 1025 kg/m^3.

The ship's propeller has a diameter of 5.5 m, a pitch ratio of 0.9 and a blade area ratio of 0.45.

With the propeller operating at 1.8 rev/sec, the following results were recorded:

apparent slip ratio	=	0.05
thrust power	=	3250 kW
propeller efficiency	=	66%

Calculate EACH of the following for the above condition:

(a) the ship's speed; (3)

(b) the real slip ratio; (6)

(c) the thrust per unit area of blade surface; (4)

(d) the torque delivered to the propeller. (3)

The Taylor wake fraction is given by: $w_t = 0.5\,C_b - 0.05$

7. With reference to fatigue failure:

(a) state the conditions that must be present so that a fatigue failure may be initiated; (3)

(b) sketch a typical fatigue curve (S versus N curve) for a material exhibiting a *fatigue limit*; (3)

(c) state the final fracture mechanism that results from a fatigue failure, describing the factors that contribute to this final failure; (5)

(d) describe, with reasons, which regions of the hull may be susceptible to fatigue failure. (5)

8. (a) Describe TWO functions that trials data fulfils on a newly built ship, other than for satisfying owners of ship performance at sea. (4)

(b) State the TWO types of speed trial carried out. (2)

(c) State the requirements of a measured mile trials course. (4)

(d) List the conditions to be satisfied on a speed trials run. (4)

(e) Explain why trial runs are carried out in double runs. (2)

9. With reference to watertight sub-division of a ship:

(a) describe the purpose of watertight bulkheads; (2)

(b) define EACH of the following terms:

(i) bulkhead deck; (1)

(ii) margin line; (1)

(iii) floodable length; (1)

(iv) permissible length; (1)

(v) factor of sub-division. (1)

(c) state the criterion that decides whether or not a ship has foundered; (1)

(d) state the TWO variables that the factor of sub-division depends upon; (2)

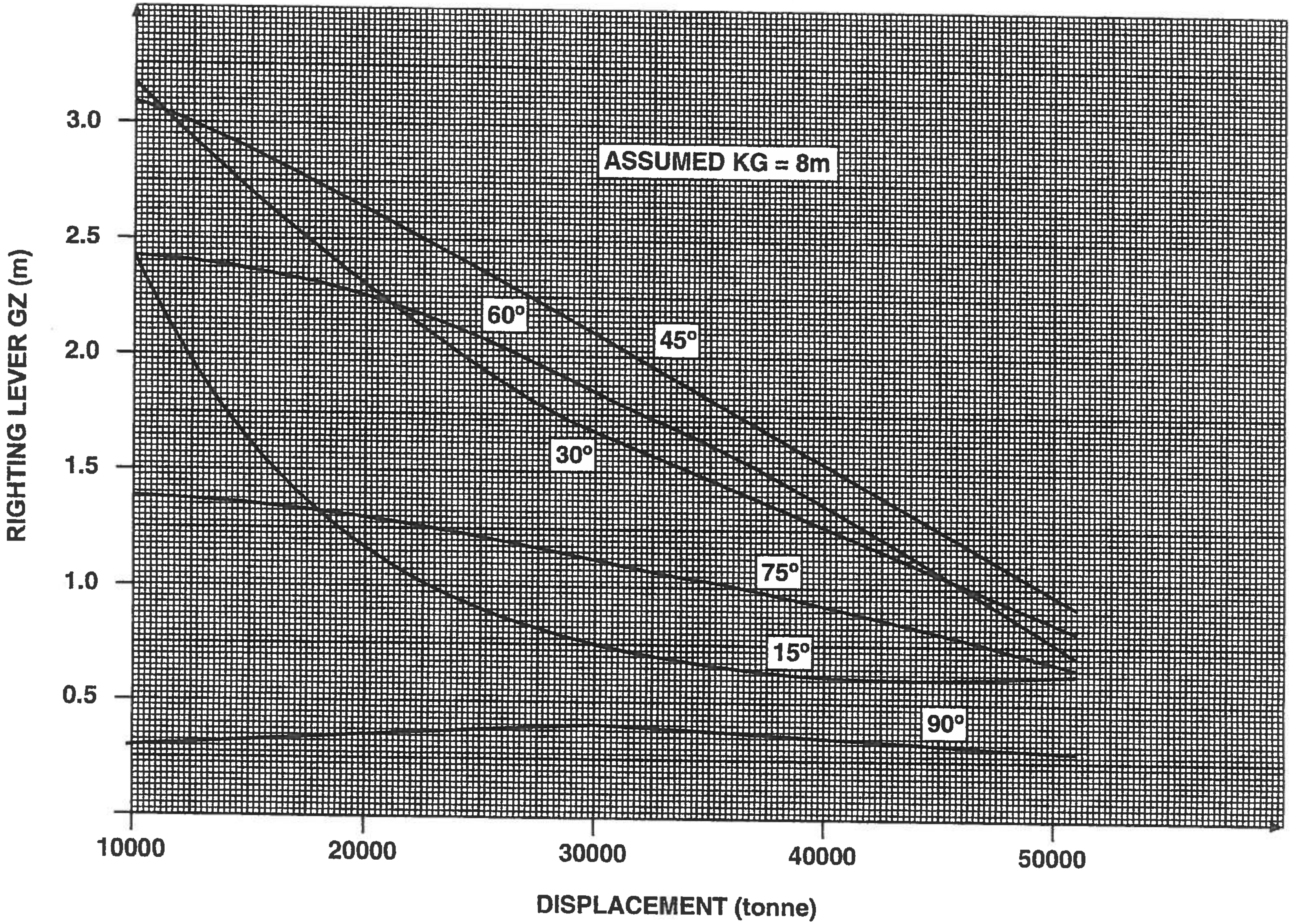
(e) describe the stability requirements with respect to metacentric height and angle of list for a vessel that has sustained *reasonable* damage. (6)

Paper 86

~~22 JULY 2011~~

WORKSHEET Q2

(This Worksheet must be returned with your answer book)



Candidate's Name ....

Examination Centre ....

SCOTTISH QUALIFICATIONS AUTHORITY
MARKERS REPORT FORM

SUBJECT: 041-34 Naval Architecture

DATE: 18th Dec 2015

General Comments on Examination Paper

An average mark of 57.9/96 (60.3%)

All calculation questions (Q1 to 6) were generally well answered, but the descriptive questions (Q7,8 and 9), which have all been asked in previous exams, were very poorly answered.

Comments of Specific Examination Questions

Confidential Comments

One exam centre had a very poor pass rate and not in line with the other two.

South Tyneside pass rate 86% (43 candidates)

Glasgow pass rate 90% (10 candidates)

Warsash pass rate 28.6% (14 candidates)

CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY –
MARINE ENGINEER OFFICER

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STCW 95 CHIEF ENGINEER REG. III/2 (UNLIMITED)

041-34 – NAVAL ARCHITECTURE

FRIDAY, 16 OCTOBER 2015

0915 - 1215 hrs

Examination paper inserts:

Worksheet Q3

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 ship floats at a draught of 10 m in sea water of density 1025 kg/m^3. In this condition the centre of gravity is 9.896 m above the keel and the second moment of area of the waterplane about the centreline is 94030 m^4.

   Values of tonne per centimetre immersion (TPC) in sea water are given in Table Q1.

Draught (m)	0	1	2	4	6	8	10
TPC	8.6	10.9	12.6	15.1	16.6	17.6	18.1

Table Q1

A load is to be discharged from the ship's centreline by the ship's own heavy lift crane. The crane head is 12 m above the original centre of gravity of the load and 16 m from the centreline of the ship when swung out. During the discharge it is required that the metacentric height should not be less than 1.75 m.

Calculate EACH of the following:

(a) the maximum load the crane may lift; (14)

(b) the angle to which the ship will heel when discharging the maximum load. (2)

2. (a) Sketch and 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 18000 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 stowed 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) Draw the amended statical stability curve for the ship. (12)

(ii) From the curve, determine the angle of list due to the cargo shift. (1)

3. A ship 120 m long floats at draughts of 6.6 m aft and 4.2 m forward when floating in river water of density 1008 kg/m^3.

Using the hydrostatic curves provided in Worksheet Q3, determine EACH of the following:

(a) the displacement; (8)

(b) the longitudinal position of the centre of gravity. (8)

4. A box shaped vessel is 80 m long, 10 m wide and floats at an even keel draught of 4 m in water of density 1025 kg/m^3 with a KG of 3.43 m.

A full width empty compartment at the forward end of the vessel is 10 m long and has a watertight flat 2.5 m above the keel.

This end compartment is now bilged above the flat only.

Calculate the new end draughts of the vessel. (16)

Note: The KB in the bilged condition may be taken as half the new mean draught.

5. A ship of length 156 m and breadth of 24 m floats at a draught of 8.25 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, 6 m in length, gives a total resistance of 43.55 N when tested at a speed of 1.65 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 1.23
Temperature correction $\pm$0.43% per °C
Frictional coefficient for the model in water of density 1000 kg/m^3 at 15°C is 1.655
Frictional coefficient for the ship in water of density 1025 kg/m^3 at 15°C is 1.411
Speed in m/s with index (n) for ship and model 1.825
Wetted surface area (S) = $2.57\sqrt{\Delta L}$ (m^2)
QPC = 0.72

Calculate the delivered 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)

[OVER

6. The following data 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

Determine 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)

7. (a) List SIX hazards that arise with the carriage of liquefied gas in bulk. (6)

(b) Describe, with the aid of a sketch, the details of construction of a free standing prismatic tank within a gas carrier designed to carry liquefied petroleum gas (LPG). (10)

8. (a) With reference to ship hull vibration, define EACH of the following terms:

(i) frequency; (1)

(ii) amplitude; (1)

(iii) node; (1)

(iv) anti-node; (1)

(v) mode. (1)

(b) Define the term *resonance*, explaining its significance with respect to ship vibration. (4)

(c) State THREE adverse effects of ship vibration. (3)

(d) State FOUR sources of ship vibration. (4)

9. (a) Describe, with the aid of a sketch, a set of lifeboat gravity davits. (9)

(b) List the launching procedure associated with the davits described in Q9(a). (7)

HYDROSTATIC CURVES

(This Worksheet must be returned with your answer book)

Name ....

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Centre......................................

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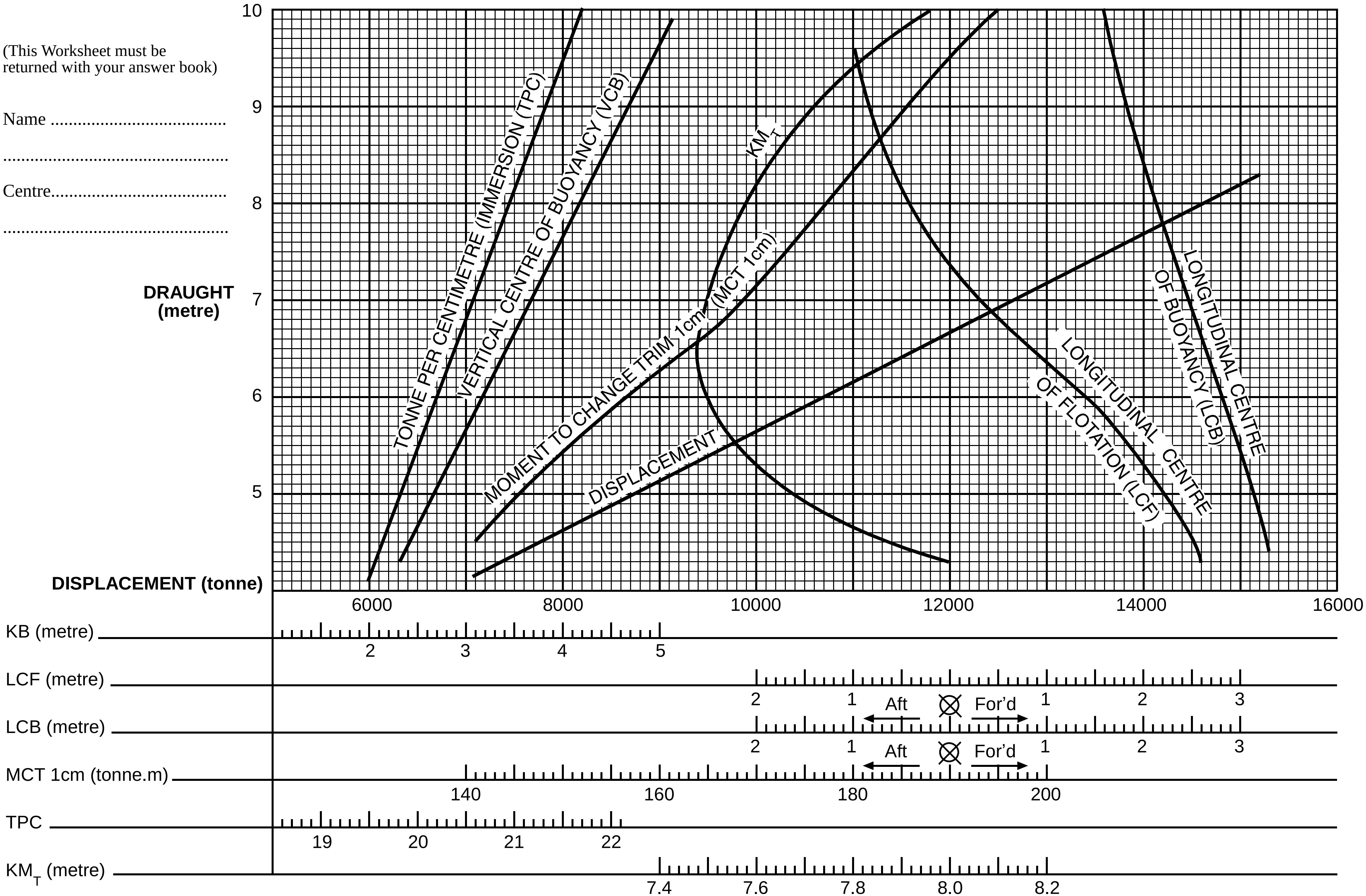

SCOTTISH QUALIFICATIONS AUTHORITY
MARKERS REPORT FORM

SUBJECT: 041-34 Naval Architecture

DATE: 16th October 2015

General Comments on Examination Paper

Some candidates coped very easily with the questions whilst others did not appear to have any knowledge at all. (Q1 is a particularly good example of this)

Overall, a disappointing response with an average mark of only 50/96 (52.1%) for a paper that comprised of questions similar to those asked in past exams.

Comments of Specific Examination Questions

Q1 (Simpson's Rules and stability) 25 candidates attempted this with 40% coping exceptionally well, but the other 60% did not cope at all.

Q2 (Large angle stability) Of the11 candidates who attempted 5 coped easily whilst the other 6 struggled.

Q3 (Trim) Although not popular, was well answered by the great majority of candidates who attempted it.

Q4 (Bilging & trim) Not popular and not well answered.

Q5 & Q6 (Resistance and Powering) As usual these were the most popular questions and they were generally very well answered.

Q7 (Gas carriers) A number of candidates confused independent tanks with membrane tanks.

Q8 (Gravity davits) A small number of candidates gave exhaustive descriptions of the braking systems and methods of testing which was not asked for.

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, 27 MARCH 2015

0915 - 1215 hrs

Examination paper inserts:

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 ship of length 160 m displaces 22862 tonne when floating at a draught of 8.526 m in sea water of density 1025 kg/m^3.

   The waterplane area is defined by half breadths as given in Table Q1.

Station	AP	1	2	3	4	5	6	7	8	9	FP
½ Breadth (m)	2	6	9	11	12	12	12	10	7	3	0

Table Q1

   The following tanks are partially full of liquid as indicated:

   rectangular tank 10.2 m long and 6 m wide, containing fresh water of density 1000 kg/m^3.
   rectangular tank 7.4 m long and 5 m wide containing oil fuel of density 890 kg/m^3.

   When a mass of 20 tonne is moved a distance of 22 m across the deck, a deflection of 71 mm is recorded on a pendulum of 9.2 m length.

   The height of the centre of buoyancy above the keel (KB) may be determined using Morrish's formula as given below.

$$KB = \frac{5}{6} \times d - \frac{\nabla}{3 \times A_W}$$

   Calculate the KG of the ship in the above condition. (16)

2. A vessel of 14000 tonne displacement floats at a draught of 8 m in sea water of density 1025 kg/m^3.

Further hydrostatic data for the above condition are:

centre of buoyancy above the keel (KB)	=	4.456 m
transverse metacentre above the keel (KM)	=	7.715 m
tonne per centimetre immersion (TPC)	=	20

The vessel in the above condition is unstable and heels to an angle of 6°.

To restore positive stability, ballast of 640 tonne is now loaded at a Kg of 0.6 m.

Calculate EACH of the following for the final condition:

(a) the transverse metacentric height; (13)

(b) the righting moment when the vessel is heeled to an angle of 15°. (3)

Note: The vessel may be considered wall-sided between the limits of draught, hence:

$$GZ = \sin\theta\,(GM + \tfrac{1}{2}\,BM\,\tan^2\theta)$$

3. The hydrostatic particulars given in Table Q3 are for a ship of length 150 m when floating in water of density 1025 kg/m^3.

Draught (m)	Displacement (tonne)	MCT 1 cm (tm)	LCB from midships (m)	LCF from midships (m)
7.5	18200	216.5	0.85 forward	2.44 aft
7.0	16800	214.0	1.07 forward	2.24 aft

Table Q3

The ship floats in water of density 1015 kg/m^3 with draughts of 7.6 m aft and 6.8 m forward.

Calculate EACH of the following:

(a) the displacement; (8)

(b) the longitudinal position of the ship's centre of gravity. (8)

4. A *spade-type* rudder has an area of 6.33 m^2. At its maximum designed rudder angle of 35°, the centre of effort is 0.12 m aft of the axis of rotation and 1.6 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:

$$F_n = 18.32\, A\, v^2\, \alpha \quad \text{newtons}$$

where: A = rudder area (m^2)
v = ship 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 16 knots; (10)

(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 375 mm. (6)

5. A ship of length 140 m and breadth 18 m floats at a draught of 8 m in sea water of density 1025 kg/m^3.

In this condition the block coefficient (C_b) is 0.68.

At a speed of 15 knots the following data applies:

delivered power	=	4720 kW
quasi-propulsive coefficient (QPC)	=	0.70
ship correlation factor (SCF)	=	1.18

Calculate the pull required to tow a similar model of length 5 m at the corresponding speed in fresh water of density 1000 kg/m^3. (16)

Note:
The frictional coefficient for the model in fresh water of density 1000 kg/m^3 is 1.694
The frictional coefficient for the ship in sea water of density 1025 kg/m^3 is 1.415
Speed in m/s with the speed index (n) for ship and model 1.825
Wetted surface area (S) = $2.57\sqrt{\Delta\, L}(m^2)$

6. The ship data in Table Q6 have been derived from the results of model experiments.

Ship speed (knots)	14	15	16
Effective power (kW)	2680	3460	4690
Thrust deduction fraction	0.195	0.192	0.185
Taylor wake fraction	0.302	0.298	0.292
Propeller efficiency	0.675	0.685	0.680

Table Q6

Using the data in Table Q6, determine EACH of the following:

(a) the ship speed when the propeller is absorbing 5250 kW delivered power; (10)

(b) the propeller speed (rev/sec) given that the propeller has a diameter of 5 m with a pitch ratio of 0.9 and is operating at a real slip of 32 %. (6)

7. (a) Container ships have very large cargo hatch openings.

Describe how this ship type is susceptible to torsion and how the structure is designed to combat torsional stress. (5)

(b) Describe the problem created by discontinuities in longitudinal structure. (2)

(c) State THREE points of discontinuity, in any ship type, describing how the problems are overcome. (9)

8. (a) Explain the requirements of an A-60 fire protection bulkhead. (4)

(b) Describe the structural arrangements for the fire protection of passenger ships. (8)

(c) Describe how the integrity of an 'A' class division is maintained where an opening has been made for an access door. (4)

9. (a) Define *critical temperature* and *boiling point* and hence show how some liquefied gases may be transported fully pressurised, whilst others need to be carried fully refrigerated. (6)

(b) State the basic differences in construction of fully pressurised and fully refrigerated systems for the carriage of liquefied gas at sea. (5)

(c) Compare the membrane tank and independent tank systems of construction. (5)

SCOTTISH QUALIFICATIONS AUTHORITY
MARKERS REPORT FORM

SUBJECT: 041-34 Naval Architecture

DATE: March 2015

General Comments on Examination Paper
A low average mark of 48.4/96 (50.4%).
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Comments of Specific Examination Questions
Q3 (large mass trim) A number of candidates wrongly used the midship draught instead of the mean draught

Q8 Clearly required a graph to be drawn but a number of candidates used interpolation instead.
Interpolation should only be used when there are only 2 values for the variables (as in Q3)

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, 19 DECEMBER 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. The load waterplane of a ship 120 m long, floating in sea water of density 1025 kg/m^3, is defined by the following half-breadths given in Table Q1.

Section	AP	½	1	2	3	4	5	6	7	7½	FP
Half- breadth (m)	1.6	3.6	5.6	7.4	8.1	8.2	8.1	6.9	4.0	2.0	0

Table Q1

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

Displacement	=	8450 tonne
centre of buoyancy above the keel (KB)	=	3.21 m
moment to change trim by one centimetre	=	101.5 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. (4)

2. An inclining test carried out on a passenger vessel at a displacement of 8725 tonne in water of density 1012 kg/m^3 resulted in an angle of heel of 1.5° when an inclining mass of 10 tonne was moved 15 m transversely across the deck.

To obtain the lightship condition for the vessel, corrections for the following masses are required:

40 tonne to be removed at Kg 9.2 m
65 tonne to be added at Kg 10.15 m

The following masses in Table Q2 are to be added to give the load condition:

Item	**Mass (tonne)**	**Kg (m)**
Passengers & effects	60	10.5
Stores	190	8.1
Oil fuel	1600	3.42
Fresh water	400	1.8

Table Q2

In the above condition, free surfaces of liquid are present in one rectangular tank 8m long and 6m wide containing fresh water of density 1000 kg/m^3 and in four rectangular tanks each 10 m long and 8 m wide containing oil fuel of density 950 kg/m^3.

Using the hydrostatic curves provided in Worksheet Q2, determine EACH of the following:

(a) the lightship KG; (7)

(b) the final mean draught in sea water; (2)

(c) the final effective metacentric height. (7)

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. The force acting normal to the centreline plane of a rudder is given by the expression:

$$F_n = 15.5 \ A \ v^2 \ \alpha \qquad \text{newtons}$$

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

A ship travelling at a speed of 20 knots has a rudder configuration as shown in Fig Q4. The centre of effort for areas A_1 and A_2 are 32% of the width from their respective leading edges. The rudder angle is limited to 35° from the ship's centreline.

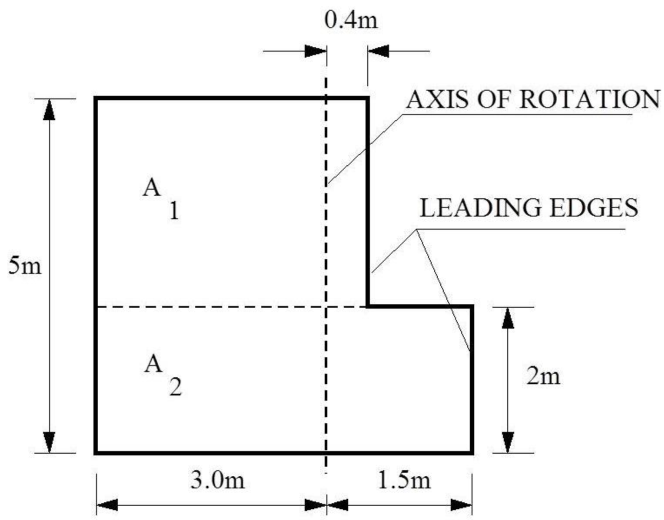

Fig. Q4

Calculate EACH of the following:

(a) the diameter of the rudder stock required for a maximum allowable stress of 77 MN/m^2; (12)

(b) the drag component of the rudder force when the rudder is put hard over at full speed. (4)

[OVER

5. The results in Table Q5 were obtained from resistance tests on a ship model 6 m in length having a wetted surface area of 7.5 m^2 in fresh water of 1000 kg/m^3 at a temperature of 13°C.

Model speed (m/s)	1.6	1.7	1.8	1.9
Total resistance (N)	40.0	46.2	55.8	70.5

Table Q5

The following particulars are also available:

Ship correlation factor 1.22
Temperature correction ±0.43% per °C

Calculate the effective power of a similar ship 160 m long travelling at a speed of 17.5 knots in sea water of density 1025 kg/m^3 at a temperature of 15°C. (16)

Note: *frictional coefficient for the model in water of density 1000 kg/m^3 at 15°C is 1.655*
frictional coefficient for the ship in water of density 1025 kg/m^3 at 15°C is 1.410
speed in m/s with index (n) for ship and model 1.825

6. A ship 145 m long and 23 m beam displaces 19690 tonne when floating at a draught of 8 m in sea water of density 1025 kg/m^3.

The following data are given for the service speed of 16 knots:

effective power (naked)	=	3450 kW
appendage and weather allowance	=	20%
quasi-propulsive coefficient	=	0.71
thrust deduction fraction	=	0.21
transmission losses	=	3%
specific fuel consumption	=	0.205 kg/kW hr

The Taylor wake fraction is obtained from:

$$w_t = 0.5\, C_b - 0.05$$

(a) Calculate EACH of the following at the service speed:

(i) the delivered power; (2)

(ii) the thrust power; (7)

(iii) the fuel consumption per day. (3)

(b) Calculate the maximum speed at which the ship must travel to complete a voyage of 3000 nautical miles, with only 200 tonne of fuel on board. (4)

7. (a) State the benefits of aluminium alloy as a construction material for a ship, describing its application. (6)

(b) State the disadvantages of using aluminium alloy. (4)

(c) Describe, with the aid of a sketch, how the problem of galvanic corrosion between a steel hull and aluminium alloy superstructure is overcome. (6)

8. (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)

9. With reference to crude oil carriers:

(a) Explain EACH of the following terms:

(i) segregated ballast tanks; (3)

(ii) clean ballast tanks; (3)

(iii) protective locations. (2)

(b) (i) Explain the crude oil washing (COW) system for cargo tank cleaning; (4)

(ii) State the advantages of crude oil washing. (4)

HYDROSTATIC CURVES

(This Worksheet must be returned with your answer book)

Name ....

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Centre......................................

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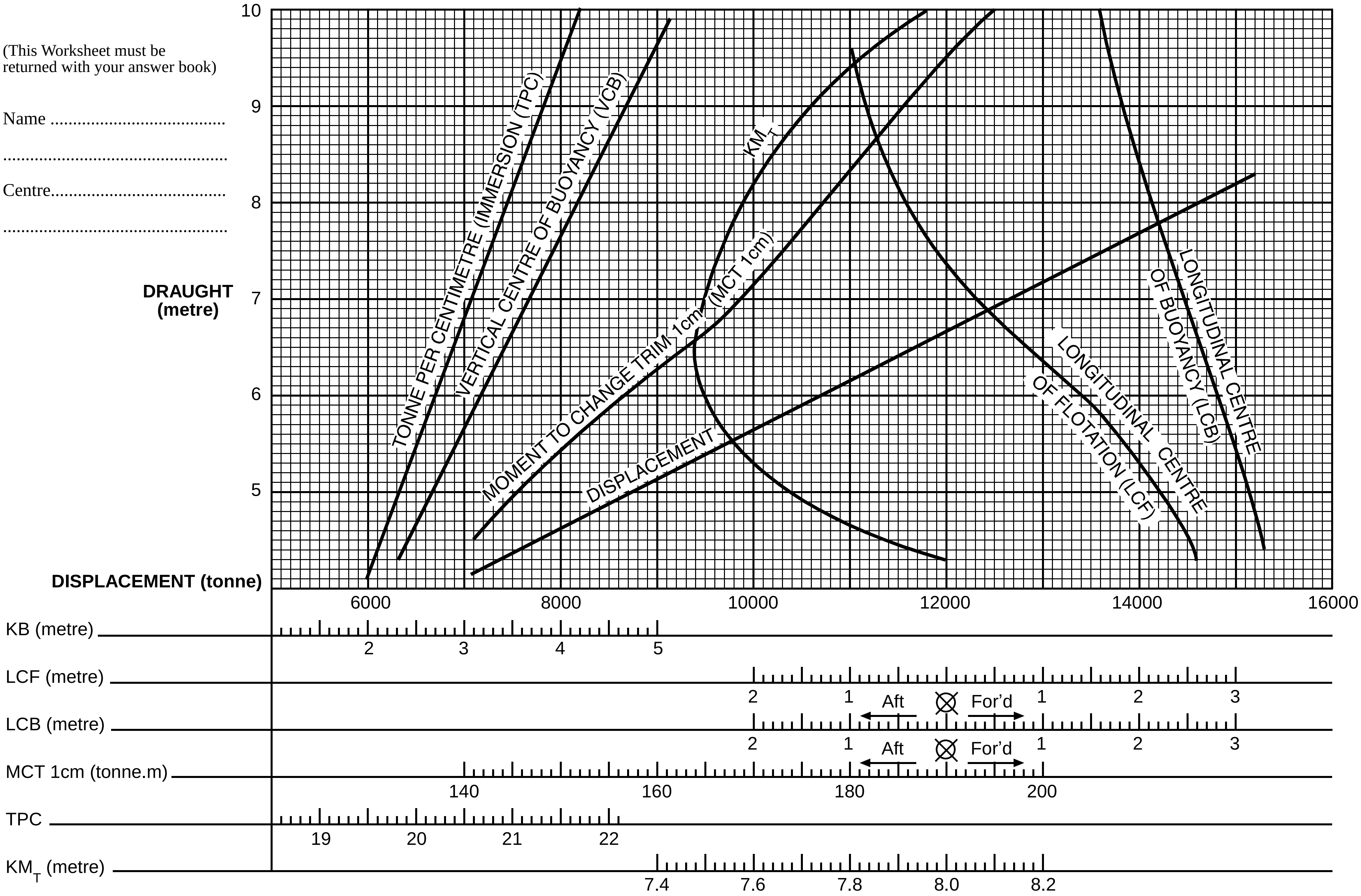

SCOTTISH QUALIFICATIONS AUTHORITY
MARKERS REPORT FORM

SUBJECT: 041-34 Naval Architecture

DATE: 19th December 2014

General Comments on Examination Paper
An average mark of 52.3/96 (54.5%).
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Comments of Specific Examination Questions
Q1 (Simpson's Rule) was not as popular or well answered as in previous exams.
Q2 (Stability & inclining experiment) was attempted by 10 candidates of whom 5 provided very good answers and 5 provided very poor answers.
Q3 (small mass trim) A number of candidates wrongly tried to answer this by the large mass method which would require an LCB and LCG which were not provided.
Q4, Q5 and Q6 (Rudders, Resistance and Powering) were all very popular and generally very well answered.
Q7 and Q9 (Descriptive questions on Materials and Pollution Control by construction) were generally well answered.
Q8 (descriptive question on the load curve) was only answered by a few candidates, however when it is presented as a calculation question it is usually popular and well answered

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, 17 OCTOBER 2014

0915 - 1215 hrs

Examination paper inserts:

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 fine form vessel of length 120 m, having immersed transverse sections in the form of semi-circles, floats in sea water of density 1025 kg/m^3.

   The load waterplane is defined by half widths as shown in Table Q1.

Section	0	½	1	2	3	4	5	5½	6
Half-width (m)	1.0	3.0	5.0	7.0	8.0	7.0	4.0	2.0	0.0

Table Q1

   Calculate EACH of the following:

   (a) the load displacement; (7)

   (b) the height of the transverse metacentre above the centre of buoyancy (BM); (7)

   (c) the block coefficient (C_b). (2)

   .

2. 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)

3. The following particulars apply to a ship of 140 m length when floating in water of density 1025 kg/m^3 at an even keel draught of 7 m:

displacement	=	14200 tonne
centre of gravity above the keel (KG)	=	8.6 m
centre of buoyancy above the keel (KB)	=	4.25 m
waterplane area	=	2049 m^2
centre of flotation from midships (LCF)	=	4.5 m aft
second moment of area of the waterplane about a transverse axis through midships	=	2.332×10^6 m^4

(a) Calculate the moment to change trim by 1 cm (MCT 1cm). (6)

(b) The ship now has the following changes of loading:

143 tonne added with its lcg 10.5 m aft of midships
80 tonne removed with its lcg at midships
60 tonne moved 40 m aft.

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

4. A box shaped barge of length 70 m has a hull mass of 420 tonne which is evenly distributed throughout its length.

Bulkheads are located 5 m from the barge ends to form peak tanks which are empty.

The remainder of the barge is divided by two transverse bulkheads to form three holds of equal length.

These holds are loaded with a total of 1680 tonne of level stowed bulk cargo, 480 tonne of which is loaded in the centre hold and the remainder is equally distributed in the other two holds.

Draw EACH of the following curves on a base of ship length:

(a) weight and buoyancy curves; (5)

(b) load curve; (3)

(c) shear force curve; (4)

(d) bending moment curve. (4)

5. The speed of a ship is reduced by 20% when 600 nautical miles from port, thereby reducing the daily fuel consumption by 42 tonne.

The ship arrives in port with 60 tonne of fuel on board.

The fuel consumption in tonne per hour is given by the expression:

$$C = 0.14 + 0.001V^3$$

where V is the ship speed in knots.

Calculate EACH of the following:

(a) the reduced daily fuel consumption; (6)

(b) the amount of fuel on board when the speed was reduced; (4)

(c) the percentage decrease in fuel consumption for the reduced speed part of the voyage; (4)

(d) the percentage increase in time for this latter part of the voyage. (2)

6. (a) With respect to a ship's propeller, explain the term *thrust deduction*. (3)

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

7. (a) Describe how a ship's propeller produces thrust. (4)

(b) Explain how the action of producing thrust may lead to propeller cavitation. (3)

(c) State the origin of vortex cavitation from the propeller cone. (1)

(d) Explain how a propeller blade may be eroded due to cavitation, describing the progressive nature of the damage. (8)

8. (a) Explain how a force normal to the rudder is produced when the rudder is turned to a helm angle. (3)

(b) Define the term *centre of effort* as applied to a rudder. (1)

(c) Describe how the position of *centre of effort* changes as helm angle increases. (2)

(d) Explain the term *balanced*, describing the benefits of fitting a balanced rudder. (3)

(e) Describe, with the aid of a sketch, how an angle of heel is produced due to the force on the rudder. (7)

9. (a) Describe with the aid of sketches, the influence on a statical stability curve of EACH of the following:

(i) an increase in the breadth of the ship with draught, freeboard and KG remaining constant; (4)

(ii) an increase in the freeboard of the ship with draught, breadth and KG remaining constant; (4)

(iii) an addition of large amounts of deckhouse on the upper deck with draught, breadth, freeboard and KG remaining constant. (4)

(b) A vessel sailing in calm conditions develops an appreciable angle of heel. There is no bilging.

Explain why this may have occurred, stating TWO actions that could be taken to restore the initial upright condition. (4)

SCOTTISH QUALIFICATIONS AUTHORITY
MARKERS REPORT FORM

SUBJECT: 041-34 Naval Architecture

DATE: 17th October 2014

General Comments on Examination Paper

A varied response to a paper

Some candidates coped very easily with the questions whilst others did not appear to have any knowledge at all.

Overall, a disappointing response with an average mark of only 43.9/96 (%) for a paper that comprised of questions similar to those asked in past exams.

Comments of Specific Examination Questions

Q4 (Load, SF and BM) Many candidates sketched the curves in the book when they should have been plotted on graph paper.

Confidential Comments

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

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)

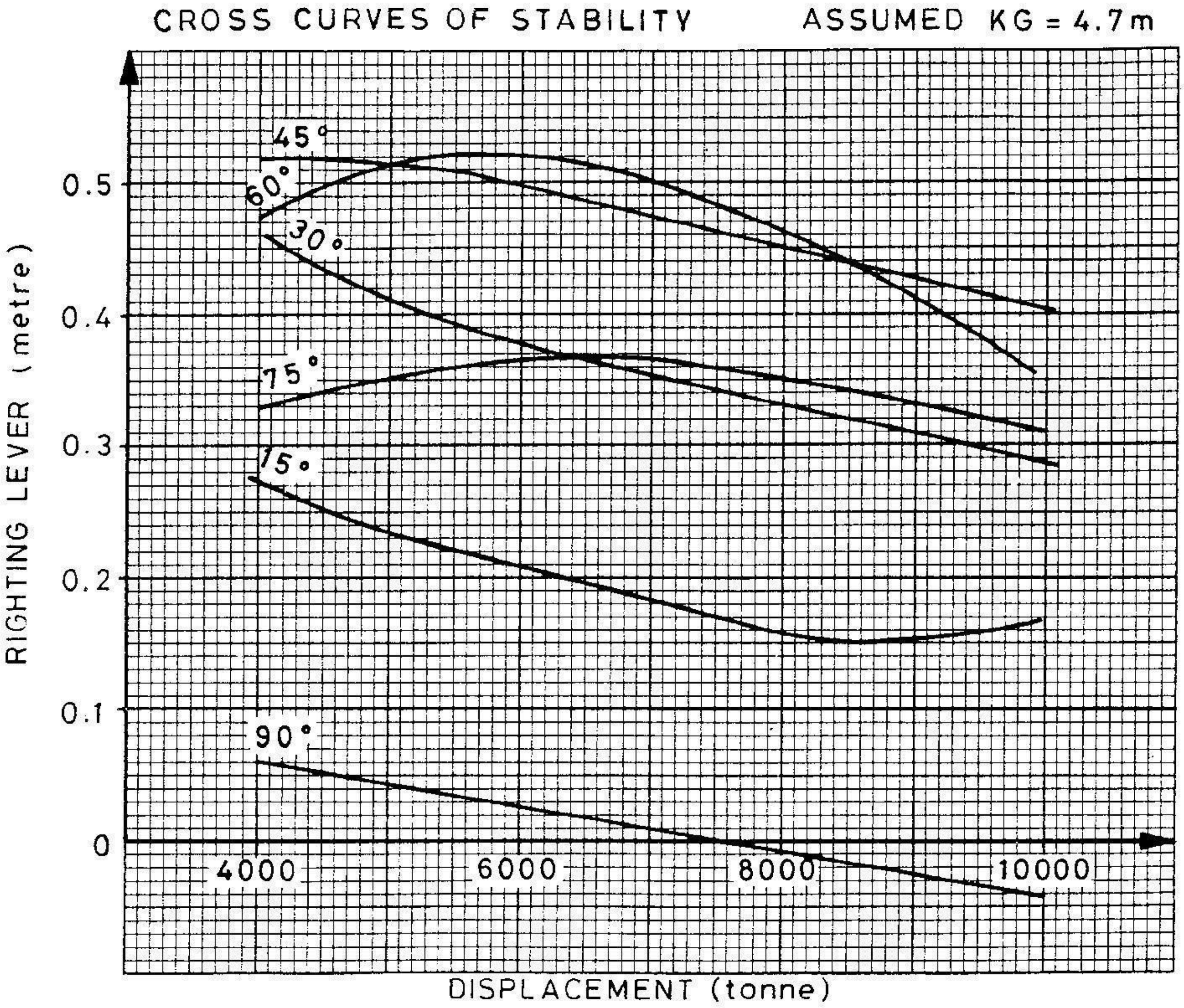
(iii) superstructure; (2)

(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)

(This Worksheet must be returned with your answer book)



Candidate's Name ……………………………………… Examination Centre ……………………………………………

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 11 APRIL 2014

0915 - 1215 hrs

Examination paper inserts:

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 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:

   5.5 5.0 4.3 3.5 and 2.5 metres

   At a displacement of 11164 tonne, the centre of gravity is 5.733 m above the keel and both tanks are partially full of oil of density 900 kg/m^3 to a depth of 0.75 m.

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

2. For a ship of 5000 tonne displacement floating in water having a density of 1025 kg/m^3, the KG is 5.19 m.

   A centre double bottom tank 12.2 m in length, 6.1 m wide and 1.6 m deep is now half filled with oil of density 900 kg/m^3.

   A mass of 100 tonne is lifted from a quayside by means of the ship's lifting gear. The top of the derrick is 18 m above the keel.

   If the KM in the final condition is 7.5 m, calculate EACH of the following:

   (a) the final effective metacentric height; (13)

   (b) the maximum outreach of the derrick if the angle of heel is not to exceed 5°. (3)

3. The hydrostatic particulars given in Table Q3 are for a ship of length 150 m when floating in water of density 1025 kg/m^3 .

Draught (m)	Displacement (tonne)	MCT 1 cm (tm)	LCB from midships (m)	LCF from midships (m)
7.5	18200	216.5	0.85 forward	2.44 aft
7.0	16800	214.0	1.07 forward	2.24 aft

Table Q3

The ship floats in water of density 1015 kg/m^3 with draughts of 7.6 m aft and 6.8 m forward.

Calculate EACH of the following:

(a) the displacement; (8)

(b) the longitudinal position of the ship's centre of gravity. (8)

4. A ship of 8000 tonne displacement has a rudder area of 22 m^2. The ship has a KM of 6.7 m, KG of 6.1 m and the centre of lateral resistance is 3.8 m above the keel. The maximum rudder angle is 35 degrees and the centroid of the rudder is 2.3 m above the keel.

The force generated normal to the plane of the rudder is given by:

$F_n = 580 \, A \, v^2 \sin \alpha$

Where: A = rudder area, v = ship speed in m/s, α = rudder helm angle

Calculate EACH of the following, when the vessel is travelling at 20 knots:

(a) the angle and direction of heel due to the rudder force only, if it is put hard over to port; (8)

(b) the angle and direction of heel due to the combination of centrifugal force and rudder force when the rudder is hard over to port and the vessel turns in a circle of 800 m diameter. (8)

5. A ship has a length of 130 m and floats in sea water of density 1025 kg/m^3. A model of this ship has a length of 5 m and a wetted surface area of 6 m^2.

The model has a total resistance of 45 N when towed at 1.85 m/s in fresh water of density 1000 kg/m^3.

(a) Using the data below, calculate EACH of the following:

(i) the ratio of residuary resistance to total resistance for the model; (5)

(ii) the ratio of residuary resistance to total resistance for the ship at the corresponding speed. (8)

(b) State why the two ratios should be different. (3)

Note: *The frictional coefficient for the model in fresh water is 1.694*
The frictional coefficient for the ship in sea water is 1.418
Speed in m/s with the speed index (n) for ship and model 1.825

6. The following data were obtained during acceptance trials for a ship of 11650 tonne displacement:

ship speed = 16 knots;

torque delivered to the propeller = 340 kNm;

propeller thrust = 465 kN;

propeller speed = 1.85 rev/s;

effective power = 2900 kW;

propeller efficiency = 67%;

apparent slip ratio = 0.06;

transmission losses = 3%.

Calculate EACH of the following:

(a) the pitch of the propeller; (3)

(b) the Taylor wake fraction; (4)

(c) the real slip ratio; (1)

(d) the thrust deduction fraction; (3)

(e) the quasi-propulsive coefficient; (2)

(f) the Admiralty Coefficient based upon shaft power. (3)

7. With reference to *brittle fracture* of a ship's hull:

(a) describe the occurrence and characteristics of brittle fracture; (6)

(b) explain the term *transition temperature*; (1)

(c) state the conditions which would make brittle fracture more likely to occur; (4)

(d) describe how a ship's hull material will resist brittle fracture in critical areas. (5)

8. (a) Explain how noise is transmitted to some position distant from the original source of that noise. (3)

(b) State SIX possible origins of noise commonly found on board ships. (6)

(c) Describe the design considerations and constructional techniques which may be used in ships to reduce the transmission of noise and to diminish noise in a given space. (7)

9. (a) State the benefits to the shipowner of a ship being classified. (4)

(b) Explain the role of the Classification Society in EACH of the following stages of a ship’s life:

(i) design; (4)

(ii) building; (4)

(iii) operation. (4)

SCOTTISH QUALIFICATIONS AUTHORITY
MARKERS REPORT FORM

SUBJECT: 041-34 Naval Architecture

DATE: 11 April 2014

General Comments on Examination Paper
A very good average mark of 65.4/96 (= 68.1%)

Comments of Specific Examination Questions

Q1 Simpsons Rules – many candidates quoted the new GM as the answer – the question asked for the change of GM

Q3 Trim – many candidates used the midship draught and did not calculate the mean draught

Q4 Angle of heel due to rudder and centrifugal forces – a number of candidates subtracted angles in part (b) when they should have subtracted tangents of the angles. The answers are similar, but that is only because of the small values of the angles of heel.

Q8 Noise – many candidates described vibration and resonance rather than noise.