October 2011

NAVAL ARCHITECTURE I

OCT 11

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 90 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.

Station	0	½	1	2	3	4	5	5½	6
Half-width (m)	0.4	2.0	4.0	6.0	7.0	6.0	3.0	1.0	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)

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2. An inclining test carried out on a passenger vessel at a displacement of 10860 tonne in water of density 1012 kg/m^3 resulted in an angle of heel of 0.85° when an inclining mass of 10 tonne was moved 20 m transversely across the deck.

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

80 tonne to be removed at Kg 8.25 m
60 tonne to be added at Kg 9.05 m.

The following masses in Table Q.2 are to be added to give the load condition:

Item	Mass (tonne)	Kg (m)
Passengers & effects	120	10.00
Stores	320	8.45
Oil fuel	1780	3.65
Fresh water	540	2.125

Table Q2

In the load condition, free surfaces of liquid are present as follows:

fresh water of density 1000 kg/m^3, in one rectangular tank, 10 m long and 10 m wide;
oil fuel of density 925 kg/m^3, in four rectangular tanks, each 8 m long and 10 m wide.

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

(a) the lightship KG; (8)

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

(c) the final effective metacentric height. (6)

3. The following particulars relate to a ship of length 225 m and breadth 36 m when fully loaded to an even keel draught of 15 m in sea water of density 1025 kg/m^3.

displacement	=	90000 tonne
waterplane area coefficient (C_w)	=	0.83
longitudinal centre of flotation from midships (LCF)	=	5 m aft
longitudinal metacentric height (GM_L)	=	230 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 15.25 aft and 13.65 forward and the following two holds are available for the remaining cargo to be loaded:

No. 1 hold with lcg 72 m forward of midships
No. 4 hold with lcg 52 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. The force acting normal to the plane of a rudder is given by the expression:

$$F_n = 20.17Av^2\alpha \quad \text{newtons}$$

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 75 kN is generated when the angle of helm is 35° with the ship travelling at 5 knots.

(a) Calculate suitable dimensions for a rectangular rudder having a depth to width ratio of 1.6. (6)

(b) The rudder stock is designed to have a diameter of 320 mm with the allowable shear stress in the material limited to 70 MN/m^2 at its service speed of 15 knots.
At the maximum helm angle of 35°, the centre of effort is 34% of the rudder width from the leading edge of the rudder.

Calculate the 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) State TWO of the MINOR components of the residuary resistance. (2)

(b) A ship has a length of 140 m and floats in sea water of density 1025 kg/m^3.
A geometrically similar model of this ship has a length of 5 m and a wetted surface area of 5.8 m^2.
The model has a total resistance of 29.55 N when towed in fresh water of density 1000 kg/m^3 at a speed corresponding to 15 knots for the ship.

Calculate EACH of the following:

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

(ii) the ratio of residuary resistance to total resistance for the ship. (7)

(c) State why the two ratios in Q5(b) should be different. (2)

Note: The frictional coefficient for the model in fresh water is 1.694
The frictional coefficient for the ship in sea water is 1.415
Speed in m/s with the speed index (n) for ship and model 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 rev/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 = 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. (a) State the criteria used as the basis for assigning freeboard. (6)

(b) To maintain an assigned freeboard requires maintenance of the *conditions of assignment.*
State the items of structure that need to comply with these requirements. (6)

(c) State TWO supplementary conditions of assignment applicable to tankers. (4)

9. (a) With reference to audible noise waves as received by the human ear:

(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)