April 2011

NAVAL ARCHITECTURE 1 APRIL 11

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 10650 tonne when floating at a draught of 7.2 m in sea water of density 1025 kg/m³. The waterplane area is defined by half breadths as given in Table Q1.

Station	AP	½	1	2	3	4	5	6	7	7½	FP
½ Breadth (m)	0	3.0	6.0	7.0	9.0	9.0	9.0	7.0	4.0	2.0	0

Table Q1

When a mass of 10 tonne is moved a distance of 16 m across the deck, a deflection of 40 mm is recorded on a pendulum of 8 m length.

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

$$KB = \left(\frac{5}{6}\times d\right)-\left(\frac{\nabla}{3\times A_w}\right)$$

Calculate the KG of the ship in the above condition. (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/m³ 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.

Calculate the angle to which the ship will heel when the tank is completely filled with fresh water of density 1000 kg/m³, assuming the ship to be wall sided over the change of draught. (16)

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3. The hydrostatic particulars given in Table Q3 are for a ship of length 150 m when floating in water of density 1025 kg/m³.

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/m³ 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 10000 tonne displacement has a rudder area of 25 m². The ship has a KM of 6.9 m, KG of 6.3 m and the centre of lateral resistance is 3.9 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:

$$F = 590\ A\ v^2 \sin \alpha$$

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

Calculate EACH of the following, when the ship is travelling at 22 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. For a ship 120 m in length and 16 m breadth, the draught is 7 m in sea water of density 1025 kg/m³ and the block coefficient is 0.7.

The effective power (naked) of the ship at a speed of 14 knots is estimated at 1900 kW.

wetted surface area (m²) = $2.57\sqrt{\Delta L}$

Calculate the pull required to tow a similar model of length 4.8 m at the corresponding speed in fresh water of density 1000 kg/m³. (16)

Note: The frictional coefficient for the model in fresh water is 1.703
The frictional coefficient for the ship in sea water is 1.421
Speed in m/s with index (n) for ship and model 1.825

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)	2620	3380	4580
Thrust deduction fraction	0.196	0.192	0.186
Taylor wake fraction	0.305	0.300	0.297
Propeller efficiency	0.685	0.695	0.690

Table Q6

Determine EACH of the following using the data in Table Q6:

(a) the ship speed when the propeller is absorbing 5050 kW delivered power; (10)

(b) the propeller speed (rev/sec) given that the propeller has a diameter of 6 m with a pitch ratio of 0.85 and is operating at a real slip of 34%. (6)

7. (a) With reference to ship hull vibration, explain, with the aid of diagrams, EACH of the following terms:

(i) two-node vertical mode; (4)

(ii) three-node horizontal mode; (4)

(b) State how hull vibration can be minimised in vessels during the design stage and on vessels already built. (8)