**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) $\quad = \quad 2.57\sqrt{\Delta L}$

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)

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' class bulkhead. (5)

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)