JULY 10

NAVAL ARCHITECTURE I

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

1. At a draught of 1.0m in sea water of density 1025 kg/m³ the displacement of a ship is 900 tonne and the height of the centre of buoyancy above the keel (KB) is 0.6m.

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

Draught (m)	1.0	1.5	2.0	3.0	4.0	5.0	6.0
TPC	12.0	12.8	13.4	14.4	15.0	15.5	15.9

Table Q1

   (a) Calculate EACH of the following for a draught of 6.0m in sea water:

   (i) the displacement; (4)

   (ii) the height of the centre of buoyancy above the keel (KB). (6)

   (b) At a draught of 6.0m, the height of the longitudinal metacentre above the keel (KM_L) is 128m and the second moment of area of the waterplane about a transverse axis through midships is 996 728m^4.

   The centre of flotation is aft of midships.

   Calculate the distance of the centre of flotation (LCF) from midships. (6)

2. A ship of 10 000 tonne displacement floats in sea water of density 1025 kg/m³ at a draught of 6m. A rectangular tank 10m long and 8m wide is partially full of oil fuel of density 900 kg/m³. In this condition, the KG of the ship is 6.25m.

   Other hydrostatic data for the above condition are:

   Centre of buoyancy above the keel (KB) = 3.325m
   Transverse metacentre above the centre of buoyancy (BM) = 4.865m
   Tonnes per centimetre immersion (TPC) = 20.5

   Calculate the change in effective metacentric height when a rectangular tank 12m long, 10m wide and 6m deep, with its base 1m above the keel, is filled to a depth of 5m with sea water ballast. (16)

   NOTE: Assume the ship to be wall-sided over the affected range of draught

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

$F_n = 15.5 \, A \, v^2 \, \alpha$ 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.

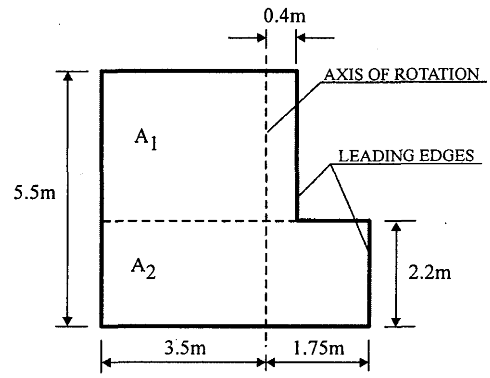

Fig Q4

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)

5. A ship consumes an average of 70 tonne of fuel per day on main engines at a speed of 17 knots. The fuel consumption for auxiliary purposes is 8 tonne per day.

When 800 nautical miles from port it is found that only 140 tonne of fuel remains on board and this will be insufficient to reach port at the normal speed.

Determine, using a graphical solution, the speed at which the ship should travel to complete the voyage with 20 tonne of fuel remaining. (16)

9. (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)