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 168 m, floating in sea water of density 1025 kg/m^3, has a displacement of 30750 tonne.

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

Station	AP	½	1	2	3	4	5	6	7	7½	FP
Half-widths (m)	2	7	10	12	13	13	12	10	6	3	0

Table Q1

The following particulars are also available:

centre of buoyancy above the keel (KB)= 4.154 m
centre of gravity above the keel (KG)= 7.865 m
centre of lateral resistance above the keel= 4.665 m

The following tanks contain slack liquid as indicated:

rectangular tank 10 m long and 8 m wide containing fresh water of density 1000 kg/m^3;

rectangular tank, 10 m long and 12 m wide, divided into two equal tanks by an oiltight longitudinal bulkhead, each tank containing fuel of density 875 kg/m^3.

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 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 being 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. 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 displacement 11000 tonne has a length 120 m, breadth 16 m, and even keel draught of 5.5 m in sea water of density 1025 kg/m^3.

The area of the waterplane is 1440 m^2 and the second moment of area of the waterplane about a transverse axis through midships is 1.2 x 10^6 m^4.

The LCF is at midships.

The ship has a full depth empty rectangular compartment having a length 12 m and breadth 10 m. The centre of the compartment is on the centreline of the ship 40 m forward of midships.

Calculate the end draughts after the compartment is bilged. (16)

Note: *For the purposes of calculating the MCT1cm it can be assumed that $GM_L = BM_L$*

5. (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)

6. A spade-type rudder has an area of 6.89 m².

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 (m²)
- 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/m².

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 145 m and breadth 23 m floats at a draught of 10 m in sea water of density 1025 kg/m³ 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/m³ gives a total resistance of 29.25 N.

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

appendage allowance	=	5%
weather allowance	=	16%
quasi-propulsive coefficient (QPC)	=	0.71
Wetted surface area (m²)	=	$2.57\sqrt{\Delta \times L}$

Note: The frictional coefficient for the model in fresh water is 1.694 m
The frictional coefficient for the ship in sea water is 1.414 – S
Speed is in m/s with index (n) = 1.825

[OVER

8. The following data were obtained during acceptance trials for a ship of 10500 tonne displacement:

ship speed:	15.5 knots
propeller torque:	320 kNm
propeller thrust:	425 kN
propeller speed:	1.8 revs/s
propeller efficiency:	65%
effective power:	2640 kW
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; (5)

(c) the real slip ratio; (1)

(d) the thrust deduction fraction; (3)

(e) the quasi-propulsive coefficient; (1)

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

9. A ship of length 130 m has a displacement of 8400 tonne and LCG 0.9 m aft of midships.

The ship is trimmed by the stern and is dry docked in this condition.

The following data in Table Q9 are available.

Draught (m)	Displacement (tonne)	LCB forward of midships (m)
6.0	10430	3.06
5.8	10000	3.08
5.6	9370	3.10
5.4	8590	3.12
5.2	7820	3.14
5.0	7230	3.16
4.8	6630	3.18
4.6	6040	3.20

Table Q9

(a) Plot a curve of moment of buoyancy about the aft end against a base of displacement. (10)

(b) Determine the upthrust exerted by the after blocks just before the ship touches the keel blocks all along its length. (6)