NAVAL ARCHITECTURE I DEC 11

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

1. A ship floats at a draught of 10 m in sea water of density 1025 kg/m^3. In this condition the centre of gravity is 10.396 m above the keel and the second moment of area of the waterplane about the centreline is 110000 m^4. Values of tonne per centimetre immersion (TPC) in sea water are given in Table Q1.

Draught (m)	0	1	2	4	6	8	10
TPC	9.2	11.8	13.6	16.3	18.0	19.0	19.5

Table Q1

A load is to be discharged from the ship's centreline by the ship's own heavy lift crane. The crane head is 15 m above the original centre of gravity of the load and 18 m from the ship's centreline when swung out.
During the discharge it is required that the metacentric height should not be less than 1.75 m.

Determine EACH of the following:

(a) the maximum load the crane may lift; (14)

(b) the angle to which the ship will heel when discharging the maximum load. (2)

2. (a) Sketch and label a statical stability curve for a vessel with its centre of gravity on the centreline but having a negative metacentric height when in the upright condition. (3)

(b) The ordinates for part of a statical stability curve for a bulk carrier at a displacement of 128000 tonne are given in Table Q2.

Angle (degrees)	0	10	20	30	45	60
Righting lever GZ (m)	0	0.453	0.996	1.409	1.633	1.486

Table Q2

The ship has a hold 48 m long and 40 m wide which contains bulk grain stowed at a stowage rate of 1.25 m^3/tonne.

During a heavy roll, the grain shifts so that the level surface is lowered by 3.0 m on one side and raised by 3.0 m on the other side.

(i) Draw the amended statical stability curve for the ship. (12)

(ii) Determine the angle of list due to the cargo shift from the curve drawn in Q2(b)(i). (1)

3. The following particulars apply to a ship of length 140 m when floating in sea water of density 1025 kg/m^3 at an even keel draught of 7.265 m.

displacement	=	15800 tonne
centre of gravity above the keel (KG)	=	7.8 m
centre of buoyancy above the keel (KB)	=	4.05 m
waterplane area	=	2146 m^2
centre of flotation from midships (LCF)	=	3.0 m aft
second moment of area of the waterplane about a transverse axis through midships	=	2.305 $\times 10^6$ m^4.

(a) Calculate the moment to change trim by one centimetre (MCT 1 cm). (4)

(b) The ship in the above condition now undergoes the following changes in loading:

352 tonne added at an lcg of 10.5 m forward of midships
110 tonne removed from an lcg of 2.0 m aft of midships
150 tonne restowed at a new position 52.7 m aft of its original position.

Calculate EACH of the following for the new condition:

(i) the new end draughts of the ship; (9)

(ii) the longitudinal position at which a mass of 204 tonne should be added to restore the ship to an even keel draught. (3)

4. A box barge of 64 m length, 8 m breadth and 4.5 m depth has a hull mass of 322 tonne evenly distributed throughout its length. Bulkheads located 2 m from the barge ends, form peak tanks which may be used for ballast. The remainder of the barge length is divided by 4 transverse bulkheads into 5 holds of equal length. The holds are full of bulk cargo having a specific volume of 1.543 m^3/t. The peak tanks are empty.

(a) Calculate the midship bending moment during discharge when both end holds are half empty. (8)

(b) Calculate the minimum depth of sea water ballast which must be added to the peak tanks to allow complete discharge of the end holds if the midship sagging bending moment is to be restricted to a maximum of 19.8 MNm. (8)

5. A ship model of length 6 m has a wetted surface area of 5.75 m^2 and is tested in water of density 1000 kg/m^3.
The test results give the values of residuary resistance for a range of model speeds as shown in Table Q5.

Model speed (m/s)	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00
Residuary resistance (N)	5.5	6.0	6.8	8.1	10.5	13.2	14.8	15.9	16.4

Table Q5

(a) (i) Plot a curve of model residuary resistance against model speed. (2)

(ii) Comment on the shape of this curve. (2)

(b) For a geometrically similar ship of length 140 m operating in sea water of density 1025 kg/m^3 at service speed of 17.25 knots, the following data is applicable:

appendage allowance	=	8%
weather allowance	=	15%
quasi-propulsive coefficient (QPC)	=	0.69
transmission losses	=	3%

Determine the shaft power required for the ship at it's service speed. (12)

Note: The frictional coefficient for the ship in sea water is 1.415
Speed in m/s with index (n) for ship and model 1.825

6. A model propeller is 0.4 m diameter and has a pitch of 0.4 m. At a speed of advance of 2 m/s in water of density 1000 kg/m^3 and at 6.8 rev/sec, the torque is 40 Nm and the thrust developed is 560 N.
A geometrically similar ship's propeller 5 m in diameter is operating in water of density 1025 kg/m^3 at corresponding linear and rotational speeds.

(a) Calculate EACH of the following for the ship's propeller:

(i) revolutions per second; (1)

(ii) speed of advance; (1)

(iii) real slip; (3)

(iv) delivered power; (3)

(v) efficiency. (4)

(b) Calculate the hull efficiency when the propeller is operating on a vessel at a Taylor wake fraction of 0.25 and a thrust deduction fraction of 0.2. (4)

Note: For similar propellers at corresponding speeds, it can be assumed;
Linear speed is proportional to (diameter)$^{1/2}$
Rotational speed is proportional to $\frac{1}{(diameter)^{1/2}}$
Thrust is proportional to (diameter)^3
Torque is proportional to (diameter)^4

7. (a) List SIX hazards that arise with the carriage of liquefied gas in bulk. (6)

(b) Describe, with the aid of a sketch, the details of construction of a free standing prismatic tank within a gas carrier designed to carry liquefied petroleum gas (LPG). (10)

8. (a) With reference to ship hull vibration, define EACH of the following terms:

(i) frequency; (1)

(ii) amplitude; (1)

(iii) node; (1)

(iv) anti-node; (1)

(v) mode. (1)

(b) Define the term *resonance*, explaining its significance with respect to ship vibration. (4)

(c) State THREE adverse effects of ship vibration. (3)

(d) State FOUR sources of ship vibration. (4)

9. With reference to the tonnage measurement of a ship:

(a) explain the difference between *Gross Tonnage* and *Net Tonnage*; (4)

(b) explain EACH of the following terms:

(i) enclosed spaces; (2)

(ii) excluded spaces; (4)

(c) state the functions of the *Tonnage Certificate*, giving examples of its use in the day to day operations of ships. (6)