NAVAL ARCHITECTURE I   OCT 10.

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

1. A ship's double bottom tank is divided by an oiltight centre girder to form equal port and starboard tanks. The tanks are 16 m long and have a constant plan area defined by equidistant ordinates from the centre girder to the sides of the ship of:

   6.0, 5.5, 4.8, 4.0 and 3.0 metres

   At a displacement of 12000 tonne in sea water of density 1025 kg/m³, the centre of gravity is 5.8 m above the keel and both tanks are partially full of oil of density 900 kg/m³ to a depth of 0.8 m.

   Calculate the change in effective metacentric height when all of the oil in both tanks has been consumed, assuming the position of the transverse metacentre to remain constant. (16)

2. A ship of 4000 tonne displacement floats at a mean draught of 6 m in sea water of density 1025 kg/m³ but is unstable and has an *angle of loll.*

   Hydrostatic particulars for the ship in the upright condition at the above displacement are as follows:

Centre of buoyancy above the keel (KB)	=	3.225 m
Height of transverse metacentre above the keel (KM)	=	5.865 m
Tonne per centimetre immersion (TPC)	=	8.0

   To achieve a satisfactory stable condition with a metacentric height of 350 mm, a load of 480 tonne at a Kg of 2.5 m is added to the ship on the centreline.

   Calculate, for the original unstable condition, EACH of the following:

   (a) the height of the original centre of gravity above the keel (KG); (12)

   (b) the angle of loll. (4)

   Note: *the vessel may be considered 'wall-sided' between the limits of draught, hence:* $GZ = \sin\theta\ (GM + \tfrac{1}{2} BM \tan^2\theta)$

[OVER

3. A vessel of constant rectangular section 80 m long and 12 m wide had a KG of 4.77 m and floats on an even keel draught of 5.5 m in water of density 1025 kg/m³. The vessel is fitted with a transverse watertight bulkhead 10 m from the forward end.

The compartment forward of the transverse bulkhead, which has a permeability of 60%, is now damaged and laid open to the sea.

Calculate the new end draughts of the vessel. (16)

4. A single screw vessel with a service speed of 15 knots is fitted with an unbalanced rectangular rudder 6 m deep and 4 m wide with an axis rotation 0.2 m forward of the leading edge. At the maximum designed rudder angle of 35° the centre of the effort is 30% of the rudder width from the leading edge.

The force on the rudder normal to the plane of the rudder is given by the expression:

$$F_n = 20.2\, A\, v^2\, \alpha \quad \text{newtons}$$

Where: A = rudder area (m²)
v = Ship speed (m/s)
α = rudder helm angle (degrees)

The maximum stress on the rudder stock is to be limited to 70 MN/m².

Calculate EACH of the following:

(a) the minimum diameter of rudder stock required; (9)

(b) the percentage reduction in rudder stock diameter that would be achieved if the rudder was designed as a *balanced* rudder, with the axis of rotation 1.0 m aft of the leading edge. (7)

5. When 800 nautical miles from port, the speed of a ship is reduced by 20%, thereby reducing the daily fuel consumption by 42 tonne. The ship arrives at port with 50 tonne of fuel on board. The fuel consumption in tonne per hour is given by the expression:

$$C = 0.136 + 0.001V^3$$

Where V is the ship speed in knots.

Calculate EACH of the following:

(a) the reduced daily consumption; (5)

(b) the amount of fuel on board when the speed was reduced; (3)

(c) the percentage decrease in fuel consumption for the reduced speed part of the voyage; (6)

(d) the percentage increase in time for this latter part for the voyage. (2)

6. A ship of 30800 tonne displacement has a length of 150 m, breadth of 26.5 m and floats at a draught of 10.5 m when in sea water of density 1025 kg/m³.

The ship's propeller has a diameter of 6.5 m with a pitch ratio of 0.8.

When the propeller is operating at 1.75 rev/s, the real slip is 32% and the thrust power is 6800 kW.

The thrust power is reduced to 5500 kW and the real slip increases to 35%.

It can be assumed that the thrust power is proportional to (speed of advance)³.

Calculate EACH of the following for the reduced power:

(a) ship speed; (11)

(b) the propeller speed of rotation; (3)

(c) the apparent slip. (2)

Note: *Wake fraction* $= 0.5\ C_b - 0.05$

7. With reference to fatigue failure:

(a) state the conditions that must be present so that a fatigue failure may be initiated; (3)

(b) sketch a typical fatigue curve (S versus N curve) for a material exhibiting a *fatigue limit*; (3)

(c) state the final fracture mechanism that results from a fatigue failure, describing the factors that contribute to this final failure; (5)

(d) describe, with reasons, which regions of the hull may be susceptible to fatigue failure. (5)

8. With reference to watertight sub-division of a ship:

(a) describe the purpose of watertight bulkheads; (2)

(b) define EACH of the following terms:

(i) bulkhead deck; (1)

(ii) margin line; (1)

(iii) floodable length; (1)

(iv) permissible length; (1)

(v) factor of sub-division. (1)

(c) state the criterion that decides whether or not a ship has foundered; (1)

(d) state the TWO variables that the factor of sub-division depends upon; (2)

(e) describe the stability requirements with respect to metacentric height and angle of list for a vessel that has sustained *reasonable* damage. (6)

9. With reference to the testing of a ship model in a towing tank:

(a) define the term *corresponding speed*; (2)

(b) state Froudes Law of Comparison; (2)

(c) explain how the effective power of a ship can be estimated from the model test. (12)