NAVAL ARCHITECTURE I MARCH 12

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

1. A ship of length 160 m, floats at its load draught with a displacement of 35000 tonne in sea water of density 1025 kg/m^3. The longitudinal centre of buoyancy (LCB) is 1.60 m aft of midships.

   In this condition, the forward half of the ship displaces 16000 tonne and has a centre of displaced volume (lcb) 30 m forward of midships. This part of the ship is to be replaced with a new forward half of similar length, but having new immersed cross section areas, to the same load draught, as given in Table Q1.

Section	Midships	6	7	8	9	9½	FP
Section area (m^2)	295	280	260	215	136	75	0

Table Q1

   Calculate EACH of the following for the new condition:

   (a) the displacement of the ship; (6)

   (b) the longitudinal position of the ship's centre of buoyancy. (10)

2. A vessel floating in water of density 1025 kg/m^3 with a displacement of 5000 tonne has the following hydrostatic particulars:

   mean draught = 5.0 m
   centre of buoyancy above the keel (KB) = 2.65 m
   transverse metacentre above the centre of buoyancy (BM) = 3.015 m
   transverse metacentric height (GM) = 0.665 m
   tonne per centimetre immersion (TPC) = 10.0

   Calculate the mass required to be added to the vessel at a Kg of 3 m to give a final metacentric height of 0.8 m, assuming the vessel to be wall sided over the change of draught. (16)

[OVER

3. A ship of length 150 m has the following hydrostatic particulars when floating at an even keel draught in sea water.

waterplane area	=	2000 m^2
displacement	=	13500 tonne
longitudinal metacentric height (GM_L)	=	165 m
centre of flotation from midships (LCF)	=	2.4 m aft

The ship grounds on a rock which may be assumed to be at a point 60 m forward of midships and settles such that the end draughts are 6.35 m aft and 5.65 m forward

Calculate the original draught of the ship. (16)

4. A box barge of length 50 m is of uniform construction and has a displacement of 600 tonne when empty. The barge is divided by four transverse bulkheads to form five holds of equal length.
Cargo is loaded as shown in Fig Q4, the cargo in each hold being uniformly distributed.

No. 5 hold	No. 4 hold	No. 3 hold	No. 2 hold	No. 1 hold
400 tonne	300 tonne	400 tonne	500 tonne	300 tonne

AFT FORWARD

Fig Q4

For this condition of loading:

(a) verify that the barge has an even keel draught; (2)

(b) draw to scale EACH of the following:

(i) the load diagram; (6)

(ii) the shear force diagram; (5)

(c) determine the longitudinal position of the maximum bending moment, using the diagrams drawn in Q4(b). (3)

5. A ship of length 160 m and breadth 28 m floats at a draught of 12 m in sea water of density 1025 kg/m^3 with a block coefficient of 0.7.

allowance for appendages	=	6%
allowance for weather	=	14%
quasi-propulsive coefficient (QPC)	=	0.71

A geometrically similar model 8 m in length, when tested at a speed of 1.6 m/s in fresh water of density 1000 kg/m^3 gives a total resistance of 82 N.

Calculate the service delivered power for the ship at the corresponding speed to that of the model. (16)

Note. *The frictional coefficient for the model in fresh water is 1.69*
The frictional coefficient for the ship in sea water is 1.42
Speed is in m/s with index (n) = 1.825
Wetted surface area (m)= $2.6\sqrt{\Delta \times L}$

6. (a) Explain the term *thrust deduction,* with respect to a ship's propeller. (3)

(b) The following data were obtained during a ships acceptance trials:

ship speed	=	15.6 knots
delivered power	=	2600 kW
effective power	=	1750 kW
thrus	=	280 kN
propeller efficiency	=	65%
apparent slip	=	6%

Calculate EACH of the following:

(i) the thrust deduction fraction; (3)

(ii) the Taylor wake fraction; (5)

(iii) the true slip; (3)

(iv) the hull efficiency. (2)

7. (a) Sketch outline midship sections for chemical carriers of Types 1, 2 and 3 showing the location of the cargo. (3)

(b) With reference to the outlines sketched in Q7(a), explain how the location of the cargo fulfils the requirements of the IMO Bulk Chemical Codes. (5)

(c) Explain how the design of a chemical tanker minimises the problems of incompatible cargoes. (5)

(d) Explain why corrugated bulkheads are fitted where possible, in preference to plane bulkheads in chemical carriers. (3)

8. (a) Explain the circumstances under which whipping stresses may occur in ships (4)

(b) Describe the use of stress indicators on board a ship. (4)

(c) Sketch a graph of stress versus time indicating whipping. (2)

(d) Describe the structure on a ship that would resist whipping. (6)

9. (a) State the reasons for carrying out sea trials on a newly built ship. (5)

(b) (i) Outline the purpose of progressive speed trials. (2)

(ii) Describe how such trials are conducted. (5)

(iii) State FOUR other tests which may be conducted during sea trials. (4)

1.

STN	CSA	SM	f∇	lever	fmom
⊗	295	1	295	0	0
6	280	4	1120	1h	1120h
7	260	2	520	2h	1040h
8	215	4	860	3h	2580h
9	136	$1\frac{1}{2}$	204	4h	816h
$9\frac{1}{2}$	75	$\frac{4}{2}$	150	$4\frac{1}{2}h$	675h
FP	0	$\frac{1}{2}$	0	5h	0
			3149		6231h

$h = \frac{160}{10} = 16m$

a. $\Delta_{\text{NEW FOREBODY}} = \frac{h}{3}\Sigma f_\Delta \times \rho = \frac{16 \times 3149 \times 1.025}{3} = \underline{17{,}215t}$

$\therefore \Delta_{\text{NEW}} = \Delta_{\text{OLD}} - \Delta_{\text{OLD FOREBODY}} + \Delta_{\text{NEW FOREBODY}}$ *

$= 35000 - 16000 + 17215 = \underline{36{,}215t}$

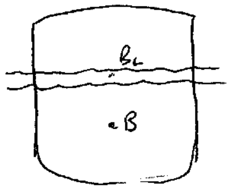
b) $\text{LCB of NEW FOREBODY} = \frac{\Sigma f\text{mom}}{\Sigma f\text{vol}} = \frac{6231 \times 16}{3149} = 31.660m$ fwd ⊗

Δ	(+ aft) LCB ~~lever~~	moment
35000	+1.6	56000
−16000	−30	+480,000
+17215	−31.660	−545027
36215		−9,027

$\text{LCB} = \frac{\text{moment}}{\Delta} = \frac{-9027}{36215} = -0.249m$

$= \underline{0.249\text{ m fwd of ⊗}}$

2.



$B_L = dr + \frac{BS}{2}$

Sinkage $= \frac{mass}{TPC}$ (cms)

$= \frac{m}{10 \times 100}$ (m) $= \frac{m}{1000}$

mass	KB	moment
5000	2.65	13250
m	$5 + \frac{m}{2000}$	$5m + \frac{m^2}{2000}$
5000+m		$13250 + 5m + \frac{m^2}{2000}$

$\therefore KB_{NEW} = \left(13250 + 5m + \frac{m^2}{2000}\right) / 5000+m$

$BM = \frac{I_ȼ \times \rho}{\Delta}$ $\quad I_ȼ = \frac{BM_1 \times \Delta}{\rho} = \frac{BM_2 \times \Delta_2}{\rho}$

$\therefore BM_{NEW} = \frac{BM_{OLD} \Delta_{OLD}}{\Delta_{NEW}} = \frac{3.015 \times 5000}{5000+m} = \frac{15075}{5000+m}$

$KG_{OLD} = KB_{OLD} + BM_{OLD} - GM_{OLD} = 2.65 + 3.015 - 0.665 = 5.0m$

mass	KG	moment
5000	5	25000
m	3	3m
5000+m		25000+3m

$\therefore KG_{NEW} = \frac{25000+3m}{5000+m}$

$GM_{NEW} = 0.8m$

$\therefore GM = KB + BM - KG$

$0.8 = \frac{13250 + 5m + \frac{m^2}{2000}}{5000+m} + \frac{15075}{5000+m} - \frac{25000+3m}{5000+m}$

$0.8(5000+m) = 4000 + 0.8m = 13250 + 5m + \frac{m^2}{2000} + 15075 - 25000 - 3m$

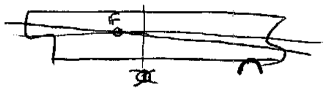
$0 = \frac{m^2}{2000} + 1.2m - 675 \quad \therefore 0 = m^2 + 2400m - 1,350,000$

$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-2400 \pm \sqrt{2400^2 - 4 \times (-1,350,000)}}{2 \times 1}$

$= \frac{-2400 \pm 3341}{2} =$ ~~4500 or -900~~ ?

470.5t

3.



$$MCT1cm = \frac{\Delta \times GM_L}{100L} = \frac{13500 \times 165}{100 \times 150} = \underline{\underline{148.5tm}}$$

$$t_c = \frac{F \times dist}{MCT1cm}$$

$$\therefore F = \frac{t_c \times MCT1cm}{dist\ from\ LCF} = \frac{(6.35-5.65) \times 100 \times 148.5}{60+2.4}$$

$$= 166.6t$$

$$TPC = \frac{Aw \times \rho}{100} = \frac{2000 \times 1.025}{100} = 20.5$$

$$Bodily\ rise = \frac{mass\ (Force)\ removed}{TPC}$$

$$= \frac{166.6}{20.5} = 8.13cm$$

$$= ~~0.813m~~\ 0.081m$$

$$dr_F = dr_{⚓} + layer\ correction$$

$$= \frac{dr_F + dr_a}{2} + \frac{LCF \times trim}{L}$$

$$= \frac{6.35 + 5.65}{2} + \frac{2.4 \times (6.35-5.65)}{150}$$

$$= 6 + 0.011m$$

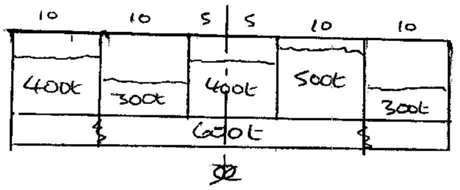
$$= \underline{\underline{6.011m}}$$

$$\therefore dr_{ORIGINAL} = dr_F + B.R$$

$$= 6.011 + 0.081$$

$$= \underline{\underline{6.092m}}$$

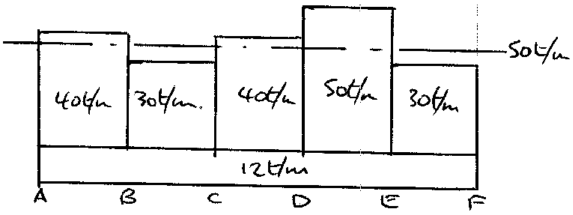
4



a)

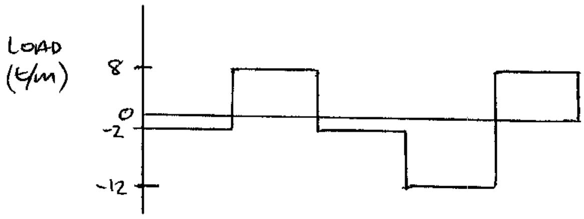
mass	LCG (+aft)	moment
600	0	0
400	+20	+8000
300	+10	+3000
400	0	0
500	+10	+5000
300	+20	+6000
2500		0

$LCG = \frac{0}{2500}$ = at midships ∴ evenkeel



$Bcy/m = \frac{2500}{50} = 50t/m$

$Hull/m = \frac{600}{50} = 12t/m$

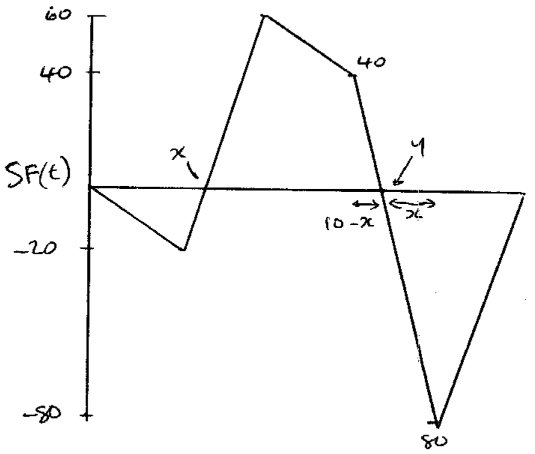


LOAD = Bcy − mass

$L_{AB} = 50-52 = -2t/m$ $L_{BC} = 50-42 = 8t/m$

$L_{CD} = 50-52 = -2t/m$ $L_{DE} = 50-62 = -12t/m$

$L_{EF} = 50-42 = 8t/m$



$SF_A = 0t$ $SF_B = -2\times10 = -20t$

$SF_C = -20 + 8\times10 = 60t$

$SF_D = 60 - 2\times10 = 40t$

$SF_E = 40 - (12\times10) = -80t$

$SF_F = -80 + 8\times10 = 0t$

max BM at 'y' because area is greater than at 'x'

$\frac{40}{10-x} = \frac{80}{x}$

$40x = 80(10-x)$
$= 800 - 80x$

$\therefore x = \frac{800}{40+80} = 6.67m$

∴ max BM at 16.67m aft of Forward end.

5.

$R_{fm} = fSV^n$

$= 1.69 \times 16.148 \times 1.6^{1.825}$

$= 64.35N$

$S_s = 2.6\sqrt{\Delta L}$

$= 2.6\sqrt{0.7 \times 160^2 \times 28 \times 12 \times 1.025}$

$= 6459 m^2$

$S_m = S_s\left(\frac{L_m}{L_s}\right)^2 = 6459\left(\frac{8}{160}\right)^2$

$= 16.148 m^2$

$R_{Rm} = R_{Tm} - R_{fm}$

$= 82 - 64.35 = 17.65N \doteq FW$

$R_{Rs} = R_{Rm}\left(\frac{L_s}{L_m}\right)^3 \times \frac{\rho_{SW}}{\rho_{FW}} = 17.65\left(\frac{160}{8}\right)^3 \times \frac{1.025}{1.000} = \underline{144730N}$.

$V_s = V_m\sqrt{\frac{L_s}{L_m}} = 1.6\sqrt{\frac{160}{8}} = 7.1554 m/s$.

$R_{fs} = fSV^n = 1.42 \times 6459 \times 7.1554^{1.825} = 332{,}783N$

$R_{TS} = R_{fs} + R_{RS} = 332783 + 144730 = 477513N$

$eP_n = R_T \times V = 477513 \times 7.1554 = 3417kW$

$eP = eP_n \times SFC = 3417 \times 1.06 \times$ ~~1.50~~ $1.14 = 4129kW$

$dP = \frac{eP}{QPC} = \frac{4129}{0.71} = \underline{\underline{5815 kW}}$

6. a)

b) (i) $e_P = R_T \times V$

$R_T = \frac{e_P}{V} = \frac{1750 \times 60 \times 60}{15.6 \times 1852} = 218\,kN$

$R_T = T(1-t) \quad t = 1 - \frac{R_T}{T} = 1 - \frac{218}{280} = \underline{\underline{0.221}}$.

(ii) $t_P = d_P \times \eta_{PROP} = 2600 \times \frac{65}{100} = 1690\,kW$

$t_P = T \times V_a \quad \therefore V_a = \frac{t_P}{T} = \frac{1690}{280} = 6.036\,m/s$
$= 11.732\,KTS.$

$w_T = \frac{V - V_a}{V} = \frac{15.6 - 11.732}{15.6} = \underline{\underline{0.248}}$.

(iii) $V_T = \frac{V}{1 - S_A} = \frac{15.6}{1 - 0.06} = 16.596\,KTS.$

$S_R = \frac{V_T - V_a}{V_T} = \frac{16.596 - 11.732}{16.596} = 0.293$

(iv) $\eta_{HULL} = \frac{e_P}{t_P} = \frac{1750}{1690} = 1.035$