

1. A WALL-SIDED BARGE FLOATING IN SALT WATER WITH A SPECIFIC VOLUME OF $35 \text{ ft}^3/\text{ton}$ HAS A DRAFT OF 9 ft. AND A CENTER OF GRAVITY OF 11 ft. ($C_B = C_P = C_m = 1.0$) THE BARGE IS 150 ft LONG, WITH A BEAM OF 50 ft, AND A DEPTH OF 20 ft. $LCC = 75 \text{ ft}$, $TCC = 0$. DETERMINE THE FOLLOWING CHARACTERISTICS:

- DISPLACEMENT
- CENTER OF BUOYANCY
- METACENTRIC RADIUS
- LONGITUDINAL METACENTRIC RADIUS
- HEIGHT OF THE METACENTER
- LONGITUDINAL HEIGHT OF THE METACENTER

- a. DISPLACEMENT

$$\Delta = LBT / 35 \quad (150)(50)(9) / 35 = 1,929 \text{ LT} = \Delta$$

- b. CENTER OF BUOYANCY ($\bar{KB}$)

$$\bar{KB} = T/2 = 9/2 = 4.5 \text{ ft} = \bar{KB}$$

- c. METACENTRIC RADIUS ($\bar{BM}$)

$$\bar{BM} = I / \nabla \cdot \frac{B^3 L / 12}{BLT} = \frac{B^2}{12T} = \frac{(50)^2}{12(9)} = 23.15 \text{ ft} = \bar{BM}$$

- d. LONGITUDINAL METACENTRIC RADIUS ($\bar{BM}_L$)

$$\bar{BM}_L = \frac{I_L}{\nabla} = \frac{BL^3 / 12}{BLT} = \frac{L^2}{12T} = \frac{(150)^2}{12(9)} = 209.3 \text{ ft} = \bar{BM}_L$$

- e. HEIGHT OF THE METACENTER ($\bar{KM}$)

$$\bar{KM} = \bar{KB} + \bar{BM} = 4.5 + 23.15 = 27.65 \text{ ft} = \bar{KM}$$

- f. LONGITUDINAL HEIGHT OF THE METACENTER ($\bar{KM}_L$)

$$\bar{KM}_L = \bar{KB} + \bar{BM}_L = 4.5 + 209.3 = 212.8 \text{ ft} = \bar{KM}_L$$

2. THE USS GEARING (DD 710) IS AT SEA WITH A DRAFT FORWARD OF 13 ft 2 in, AND A DRAFT AFT OF 13 ft 10 in. ANSWER THE FOLLOWING QUESTIONS:

- WHAT IS HER MEAN DRAFT?
- WHAT IS HER TRIM?
- WHAT IS HER TONS-PER-INCH IMMERSION?
- WHAT IS HER DISPLACEMENT IN SALT WATER?
- WHAT VOLUME OF SEAWATER IS DISPLACED AT THIS DRAFT?
- WHAT IS HER TRANSVERSE METACENTRIC RADIUS?
- WHAT IS HER WATERPLANE AREA COEFFICIENT?
- AFTER A PERIOD OF STEAMING, THE DRAFT FORWARD CHANGES TO 12 ft 11 in AND THE DRAFT AFT TO 13 ft 7 in. HOW MANY TONS OF FUEL AND STORES HAVE BEEN CONSUMED?

a. MEAN DRAFT

$$T_m = \frac{T_F + T_A}{2} = \frac{13' 2" + 13' 10"}{2} = 13' 6"$$

b. TRIM: $T_F - T_A = 13' 2" - 13' 10" = -8"$ BY THE STERN

c. TONS/INCH IMMERSION

$$\text{FROM DFD CURVES: } TPI = 1410 \left(\frac{1}{T_{100}} \right) = 28.2 \text{ LT/in}$$

d. DISPLACEMENT

$$\Delta_{\text{LVL}} = 3180 \text{ LT}$$

$$\Delta_{\text{CORRECTION}} = 992 \left(\frac{1}{T_{100}} \right) \times \frac{8}{12} = 13.2 \text{ LT}$$

$$\Delta = \Delta_{\text{LVL}} + \Delta_{\text{COR}} = 3180 + 13.2 = 3193 \text{ LT}$$

e. VOLUME OF DISPLACED SEAWATER

$$\nabla_{\text{SW}} = \Delta \left(\frac{35 \text{ ft}^3/\text{LT}}{1.025} \right) = 3193 (35) = 111,762 \text{ ft}^3$$

f. TRANSVERSE METACENTRIC RADIUS, $\overline{BM}_T$

$$\text{FROM DFD CURVES: } \overline{KM}_T = 968 \left(\frac{1}{T_{100}} \right) = 19.36 \text{ ft} \quad \overline{KB} = 81 \left(\frac{1}{T_{100}} \right) = 8.11 \text{ ft}$$

$$\overline{BM}_T = \overline{KM}_T - \overline{KB} = 19.36 - 8.11 = 11.25 \text{ ft}$$

g. VERTICAL PLANE AREA COEFFICIENT, C_{vp}

$$C_{vp} = \frac{A_{vp}}{BL}$$

$$\text{from DIS CURVES: } A_{vp} = 119. (15) = 11,325 \text{ ft}^2$$

$$C_{vp} = \frac{11,325}{40.6 \times 333} = 0.763$$

h. CHARGE IN POUNDS OF TONS OF FUEL/STOKES CONSUMED.

$$\text{ASTA STANDARD, } T_m = \frac{12' 11" + 13' 7" + 13' 5"}{2}$$

2 WAYS.

$$\text{I. } TPI \Rightarrow 29.2 \text{ TPI}$$

$$\delta T_m = T_m - T_{m_0} = 13' 6" - 13' 3" = 3"$$

$$\delta \Delta = 3 (29.2) = 87.5 \text{ LT}$$

$$\text{II. } T_m = 13' 3"$$

$$T_{trim} = -8" \text{ BY THE STEAM}$$

$$\Delta_{LVL} = 3042 \text{ LT}$$

$$\Delta_{COR} = 995 \left(\frac{2}{700} \right) \times \frac{9}{12} = 13.2 \text{ LT}$$

$$\Delta_1 = 3042 + 13.2 = 3155.2$$

$$\delta \Delta = 3193 - 3155.2 = 37.8 \text{ LT}$$

3. A SHIP WITH LBP = 168 ft HAS THE FOLLOWING DWL OFFSETS :

STATION	0 = FP	1	2	3	4	5	6	7	8 = AP
1/2 B (ft)	1.5	4.9	8.7	11.3	12.4	12.1	10.75	7.9	3.4

a. WHAT IS THE AREA OF THE DWL ?

b. WHERE IS THE LCF LOCATED ?

STA	HALF B	SIMP MULT	PRODUCT	LEVER	PRODUCT
0	1.5	1	1.5	4	6
1	4.9	4	19.6	3	58.8
2	8.7	2	17.4	2	34.8
3	11.3	4	45.2	1	45.2
4	12.4	2	24.8	0	0
5	12.1	4	48.4	-1	-48.4
6	10.75	2	21.5	-2	-43
7	7.9	4	31.6	-3	-94.8
8	3.4	1	3.4	-4	-13.6
			$\Sigma_1 = 213.4$	$\Sigma_2 = -55$	

a. A_{wp} AT DWL

$$L = 168 \Rightarrow s = \frac{L}{8} = 21$$

$$A_{wp} = \Sigma_1 \times \frac{2}{3} \times s = (213.4) \left(\frac{2}{3} \right) (21) = 2,987.6 \text{ ft}^2$$

b. LONGITUDINAL CENTER OF FLUTATION, LCF

$$LCF = \left(\frac{\Sigma_2}{\Sigma_1} \right) \times s = \frac{-55}{213.4} \times 21 = -5.41 \text{ ft}$$

LCF : 5.41 ft AFT OF STATION 4.

4. HALF-BREATHS OF AN OCEAN-GOING VESSEL'S WATERPLANE ARE GIVEN IN THE TABLE BELOW. THE SHIP HAS A LENGTH OF 633.2 ft, A DRAFT OF 31.1 ft, A BEAM AS INDICATED IN THE DATA, AND A DISPLACEMENT OF 30,257 LT.

USE SIMPSON'S FIRST RULE TO COMPUTE

- WATERPLANE AREA
- LONGITUDINAL LOCATION OF THE CENTER OF FLUTATION
- LONGITUDINAL MOMENT OF INERTIA ABOUT THE WATERPLANE'S CENTROID
- WATERPLANE TRANSVERSE MOMENT OF INERTIA ABOUT ITS CENTROID
- TRANSVERSE METACENTRIC HEIGHT, KM.

STATION	HALF-BREADTH (ft)
0	0.561
1/2	4.265
1	12.49
2	27.23
3	38.372
5	42.759
7	42.536
8	40.062
9	28.920
9 1/2	20.033
10	9.560

STA	HALF	1/2 sm	PRODUCT	LEVER	PRODUCT	LEVER ²	PRODUCT	(HALF) ³	PRODUCT
0	0.561	0.25	0.140	5	6.701	25	3.506	.1766	0.044
1/2	4.265	1	4.265	4.5	19.193	20.45	86.367	77.58	77.581
1	12.49	0.75	9.368	4	37.97	16	149.88	1948.44	1461.3
2	27.23	2	54.460	3	163.38	9	490.14	20,190	40,380.6
3	38.372	1	38.372	2	76.744	4	153.48	56,499	56,499
4	42.759	2	85.518	1	85.513	1	85.513	78,177	156,355
5	42.759	1	42.759	0	0	0	0	78,177	78,177
6	42.759	2	85.518	-1	-85.518	1	85.518	78,177	156,355
7	42.536	1	42.536	-2	-85.072	4	170.144	76,960	76,960
8	40.062	2	80.124	-3	-240.372	9	721.116	64,296	128,596
9	28.920	0.75	21.69	-4	-86.760	16	347.040	24,187	18,140
9 1/2	20.033	1	20.033	-4.5	-90.149	20.45	405.67	8,039	8,039.6
10	9.560	0.25	2.39	-5	-11.05	25	59.75	473.7	218.43

$$\Sigma_1 = 487.17$$

$$\Sigma_2 = -216.81$$

$$\Sigma_3 = 2750.14$$

$$\Sigma_4 = 721,263$$

$$L = 633.2 \text{ ft} \Rightarrow S = L/10 = 63.32 \text{ ft}$$

a. WATERPLANE AREA

$$A_{wp} = \sum x \times \frac{4}{3} \times S = (457.17) \left(\frac{4}{3} \right) (63.32) = 41,130.4 \text{ ft}^2 = A_{wp}$$

b. LONGITUDINAL CENTER OF FLOTATION, LCF

$$LCF = \left(\sum x / 2 \right) \times \left(\frac{-216.81}{457.17} \right) + (63.32) = -28.19 \text{ ft}$$

$$LCF = 28.19 \text{ ft AF- OF STAS}$$

c. LONGITUDINAL MOMENT OF INERTIA ABOUT THE WATERPLANE'S CENTROID

$$\text{FIRST, } I_{cm} = \sum x \times 2 \times \frac{2}{3} \times S^3$$

$$I_{cm} = (2758.14) \times \left(\frac{4}{3} \right) \times (63.32)^3 = 933,636,370.7 \text{ ft}^4$$

$$I_L = I_{cm} + A_{wp} d^2 = 933,636,370.7 + (41,130.4)(28.19)^2$$

$$I_L = 900,072,575.5 \text{ ft}^4$$

d. WATERPLANE TRANSVERSE MOMENT OF INERTIA ABOUT ITS CENTROID

$$I_T = \sum x + 2 \times \frac{2}{3} \times \frac{S}{3} = (721,263) \left(\frac{4}{9} \right) (63.32) = 20,297,943.9 \text{ ft}^4$$

e. TRANSVERSE METACENTRIC HEIGHT

$$\nabla = A \times 35 \text{ ft}^3 / 35 = 30,257 \times 35 = 1,059,001.9 \text{ ft}^3$$

$$\text{USING MORRISSEY FORMULA TO FIND } KB = \frac{1}{3} \left[S T/2 - (V/A_{wp}) \right]$$

$$KB = \frac{1}{3} \left[\frac{S(31.1)}{2} - \frac{1,059,001.9}{41,130.4} \right] = 17.33 \text{ ft}$$

$$BM_T = \frac{I_T}{\nabla} = \frac{20,297,943.9}{1,059,001.9} = 19.17 \text{ ft}$$

$$KM_T = KB + BM_T = 17.33 + 19.17 = 36.5 \text{ ft}$$