

A VESSEL OF UNIFORM CROSS-SECTION, BEAM B , LENGTH L , IS FLOATING IN SEAWATER AT DRAFT T .

a. DEVELOP AN EXPRESSION FOR THE TRANSVERSE METACENTER ABOVE THE KEEL IN TERMS OF T AND B .

b. FOR $B = 30$ ft, PLOT $\bar{KB}$ AND $\bar{KM}$ FOR DRAFTS OF 2 TO 12 ft.

c. DETERMINE THE DRAFT AT WHICH $\bar{KM}$ IS MINIMUM.

$$a. \nabla = LBT \quad \therefore I = LB^3/12$$

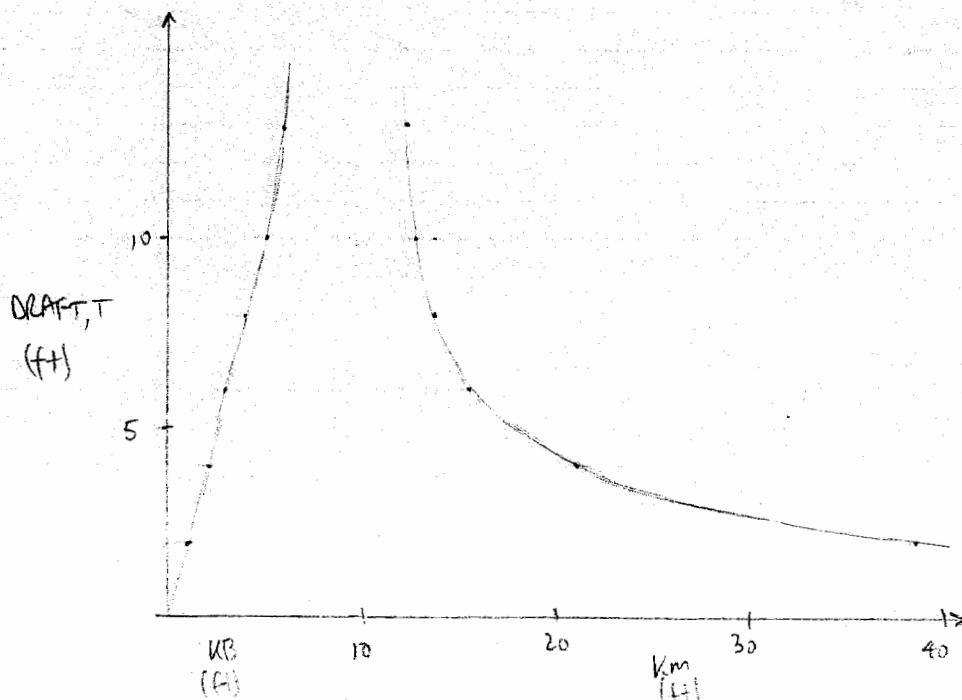
$$BM = I/\nabla = LB^3/12LBT = B^2/12T$$

$$KB = T/2$$

$$KM = KB + BM = \frac{T}{2} + \frac{B^2}{12T}$$

$$b. B = 30 \text{ ft} : KM = \frac{T}{2} + \frac{(30)^2}{12T} = \frac{T}{2} + \frac{75}{T}$$

T	$T/2 (=KB)$	$75/T$	KM
2	1	37.5	38.5
4	2	18.75	20.75
6	3	12.5	15.5
8	4	9.375	13.375
10	5	7.5	12.75
12	6	6.25	12.25



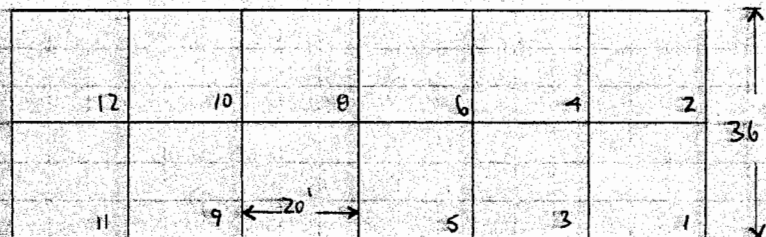
c. T for which $\overline{km}$ is minimum

$$km = \frac{T}{2} + \frac{B^2}{12T}$$

$$\frac{dkm}{dT} = \frac{1}{2} - \frac{B^2}{12T^2} = 0$$

$$T^2 = \frac{B^2}{6} \Rightarrow T = \frac{B}{\sqrt{6}}$$

$$T = \frac{30}{\sqrt{6}} = 12.247 \text{ ft}$$



A BOX SHAPED LIGHTER, SHOWN ABOVE, IS 120 feet LONG, 36 feet WIDE, AND 15 ft HIGH. WHEN EMPTY, THE BARGE DRAWS 1.7 feet IN SEAWATER AND HAS A KG OF 3.6 feet. IT IS DIVIDED INTO 12 TANKS, EACH 20 ft LONG AND 18 ft WIDE. THE GEOMETRIC CENTER OF EACH TANK IS 7.9 feet OFF THE KEEL AND 9 feet OFF THE CENTERLINE. EACH TANK HAS A CAPACITY OF 75 TONS OF OIL. CALCULATE THE ANGLE OF LIST OF THE BARGE WHEN TANKS 3 AND 9 ARE FILLED, ASSUMING THEY HAVE FREE SURFACE AND $\delta_T = 0.86$.

$$\Delta_1 = \Delta_s + w_s + w_g = \frac{BLT}{35} + w_s + w_g$$

$$\Delta_1 = \frac{(36)(120)(1.7)}{35} + 75 + 75 = 359.8 \text{ T}$$

$$\overline{KG}_1 = \frac{\Delta_s \overline{KG}_s + \sum w_i \overline{KG}_i}{\Delta_1} = \frac{(209.8)(3.6) + 75(7.9) + 75(7.9)}{359.8} = 5.39 \text{ ft}$$

$$FSC = \frac{\delta_T}{\delta_s} \frac{i}{\nabla_s} \Rightarrow i = \frac{b^3 l}{12} = \frac{(18)^3 (20)}{12} = 9720 \text{ ft}^4$$

$$FSC = \frac{\delta_T}{\delta_s} \frac{(i_s + i_g)}{\nabla_s} = \frac{0.86}{1.025} \frac{(9720 + 9720)}{35(359.8)} = 1.295 \text{ ft}$$

$$\overline{GM} = \overline{KM} - \overline{KG} = \frac{T_1}{2} + \frac{B^2}{12T_1} - \overline{KG}_1$$

$$T_1 = \frac{\Delta_1 (35)}{LB} = \frac{(359.8)(35)}{(20)(36)} = 2.915 \text{ ft}$$

$$\overline{GM}_1 = \frac{2.915}{2} + \frac{(36)^2}{12(2.915)} - 5.39 = 33.12 \text{ ft}$$

$$\overline{GM}_{\text{eff}} = \overline{GM}_1 - FSC = 33.12 - 1.295 = 31.82 \text{ ft}$$

$$\tan \phi = \frac{wt}{\Delta_1 \overline{GM}_{\text{eff}}} \Rightarrow \phi = \tan^{-1} \left[\frac{(150)(9)}{(359.8)(31.82)} \right] = 6.72^\circ \text{ STBD}$$

THE FOLLOWING INFORMATION IS FROM AN INCLINING EXPERIMENT
TEST DATA SHEET:

INCLINING WEIGHTS

NO.	WEIGHT (T)	VCG (ft)	LCG (ft)
1	4.93	39.7	67.5 aft
2	4.89	39.5	71.5 aft

WEIGHT SHIFTS

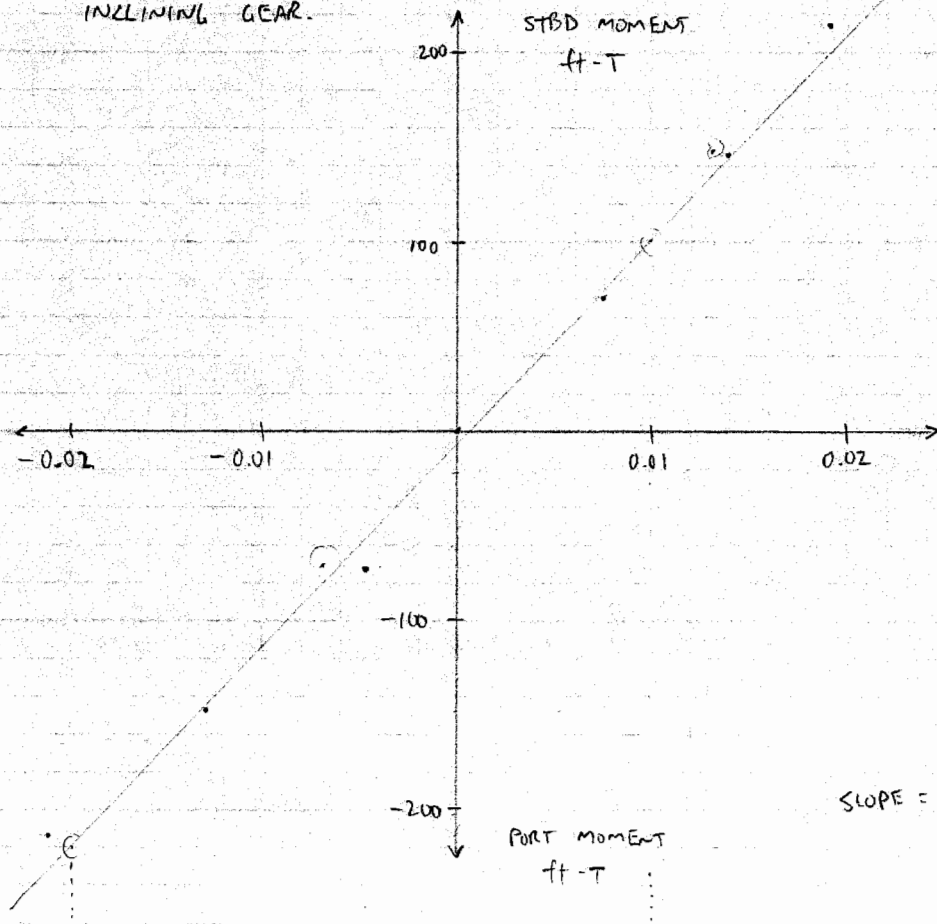
MOMENTS P, ft-T	TAN ϕ	MOMENTS S, ft-T	TAN ϕ
72	0.0068	216	0.0190
216	0.0212	145	0.0139
145	0.0131	72	0.0076
0	0	216	0.0197

Δ IN SALTWATER, 3702 T (w/GEAR)

CORRECTION FOR FREE SURFACE, 0.25 ft

$\overline{KM} = 24.0$ ft.

DETERMINE THE $\overline{KG}$ AS INCLINED AND THE $\overline{KG}$ WITHOUT THE
INCLINING GEAR.



$$\text{SLOPE} = \frac{320 \text{ ft-T}}{.03} = 10,667 \text{ ft-T}$$

$$\overline{GM}_{(AS\ INCLINED)} = \frac{wt}{\Delta \tan \phi} = \frac{slope}{\Delta}$$

$$\overline{GM}_{AS\ INCL} = \frac{10,667\ ft-T}{3702\ T} = 2.88\ ft$$

$$\overline{GM}_{AS\ INCL} = \overline{GM}_1 - FSC$$

$$\overline{GM}_1 = \overline{GM}_{AS\ INCL} + FSC = 2.88 + 0.25 = 3.13\ ft$$

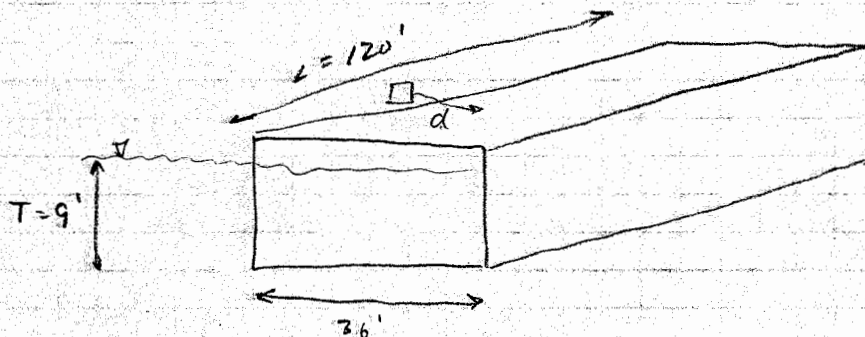
$$AS\ INCLINED, \overline{KG}_1 = \overline{KM}_1 - \overline{GM}_1 = 24 - 3.13\ ft = 20.87\ ft = \overline{KG}_{INCL}$$

$$\overline{KG}_0 (w/o\ INCLINING\ GEAR) = \frac{\Delta \overline{KG}_1 - \sum w_i \overline{KG}_i}{\Delta}$$

$$= \frac{(3702)(20.87) - (4.93)(39.7) - (4.89)(39.5)}{3692.2}$$

$$\overline{KG}_0 = 20.82\ ft$$

7. (G1J, 6-7). A RECTANGULAR BARGE 120 ft LONG AND 36 ft WIDE IS FLOATING UPRIGHT IN FRESH WATER WITH A DRAFT OF 9 ft. A 40 LT WEIGHT, WHICH IS ALREADY ON BOARD, IS LOCATED 20 ft ABOVE THE KEEL. HOW FAR MUST IT BE MOVED ATHWARTSHIPS TO PRODUCE A 3° LIST TO PORT? THE $\overline{KG}$ OF THE LOADED BARGE IS 10 ft.



$$\Delta = \frac{LBT}{36} = \frac{(120)(36)(9)}{36} = 1080 \text{ LT}$$

$$\text{RIGHTING MOMENT} = \overline{GZ} \Delta = \Delta \overline{GM} \sin \phi = (40 \text{ LT}) \times d$$

$$\overline{GM} = \overline{KM} - \overline{KG} = \overline{KB} + \overline{BM} - \overline{KG}$$

$$\overline{GM} = \frac{I}{2} + \frac{B^2}{12T} - \overline{KG} = \frac{9}{2} + \frac{(36)^2}{12(9)} - 10 = 6.5 \text{ ft}$$

$$d = \frac{\Delta \overline{GM} \sin \phi}{40 \text{ LT}} = \frac{(1080)(6.5) \sin 3^\circ}{40}$$

$$d = 9.2 \text{ ft TO PORT}$$

5. (G.I., 6-13). A DD-692 CLASS DESTROYER IS PREPARING TO ENTER DRY DOCK FOR A MAJOR OVERHAUL JUST BEFORE ENTERING THE DRY DOCK, $\overline{KL}$ IS DETERMINED TO BE 15.5 FT. THE DRAFTS FORE AND AFT ARE EQUAL TO 14 FT 6 INCHES, AND THERE IS NO LIST. WHAT WILL BE THE LEVEL OF WATER ABOVE THE KEEL OF THE SHIP WHEN THE TRANSVERSE METACENTRIC HEIGHT BECOMES ZERO?

FROM DTD CURVES, $\Delta = 3520$ LT, $\overline{KM} = 19.1$ FT

$$\overline{GM}_0 = \overline{KM} - \overline{KL} = 19.1 - 15.5 = 3.6 \text{ FT.}$$

$$\overline{GM}_{\text{DOCK}} = \frac{F_B \overline{KM} - \Delta_0 \overline{KL}_0}{F_B}$$

T (FT)	F_B (T)	$\overline{KM}$	$(F_B)(\overline{KM})$	$\Delta_0 \overline{KL}_0$	$\overline{GM}_{\text{DOCK}}$
13'	3050	19.1	58,255	54,560	1.21
12' 6"	2840	19.8	56,232	54,560	0.59
12'	2675	20'	53,500	54,560	-0.40

