2-1 A small boat weighing 40 LT has a submerged volume of 875 ft^3 when traveling at 20 kts in seawater. ($\rho = 1.99\frac{lb\cdot s^2}{ft^4}$; $1\ LT = 2240\ lb$)

(a) Calculate the magnitude of the hydrostatic support being experienced by boat.

$F_{Buoyancy} = \rho g V_{sub} = 1.99\frac{lb\cdot s^2}{ft^4} \cdot 32.2\frac{ft}{s^2} \cdot 875\ ft^3 = 56{,}068\ lb \cdot \frac{1\ LT}{2240\ lb} = 25\ LT$

(b) What other type of support is the boat experiencing?

In addition to hydrostatic support, this boat is experiencing hydrodynamic support/lift.

(c) Calculate the magnitude of this other type of support.

$F_{Hydrodynamic} = W_{boat} - F_{Buoyancy} = 40\ LT - 25\ LT = 15\ LT$

(d) What will happen to the submerged volume of the boat if it slows to 5 knots? Explain your answer.

Hydrodynamic lift is proportional to V_{boat}^2. As the boat slows, the reduction in hydrodynamic support will cause the boat weight to exceed the total lift so the boat will sink down (draft, T, will increase). As T increases, V_{sub} increases so $F_{buoyancy}$ increases until a new equilibrium is reached at a new, deeper, draft.

EN 200	CH 2	Prob 2 & 3

2. Both hovercraft and surface effect ships are supported by air cushions while moving across the water.

ACV's : - ride on top of water, allowing amphibious capability
- high speed vessel
- expensive to operate
- small payloads
- poor disectional stability

SES : - rides on air cushion, however, rigid sides extending into water allow greater directional stability and require less energy expended to maintain air cushion.
- higher payload than ACV.
- no amphibious capability
- expensive to operate

3. a. SWATH = Small Waterplane Area Twin Hull

b. Supported by hydrostatic forces while underway.

c. Advantages of SWATH:

- very stable platform ⇒ good sea keeping
- large deck area
- fuel efficient

2-4 Sketch a profile of a ship and show the following:

(a) Forward Perpendicular

(b) After Perpendicular

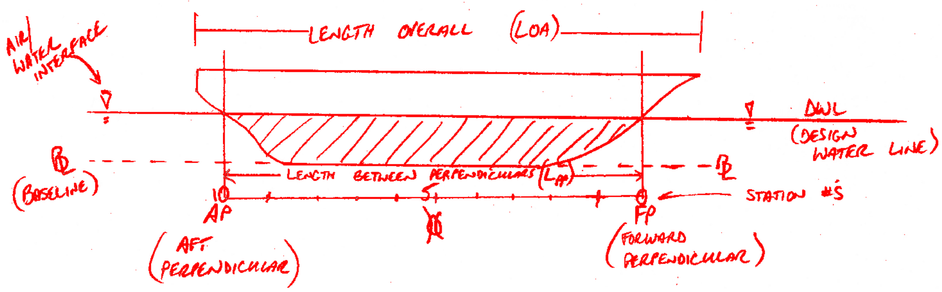
(c) Sections, assuming the ship has stations numbered 0 through 10.

(d) Length Between Perpendiculars

(e) Length Overall

(f) Design Waterline

(g) Amidships



2-5 Sketch a section of a ship and show the following:

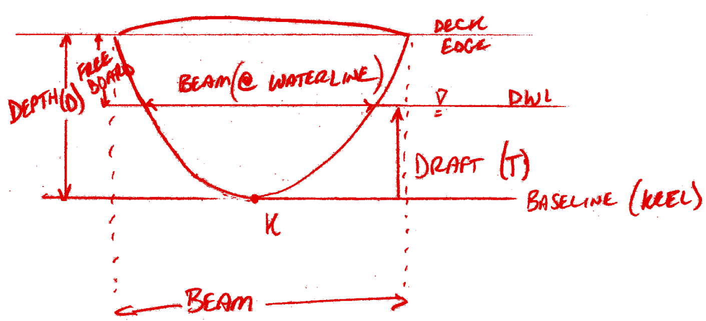
(a) Keel

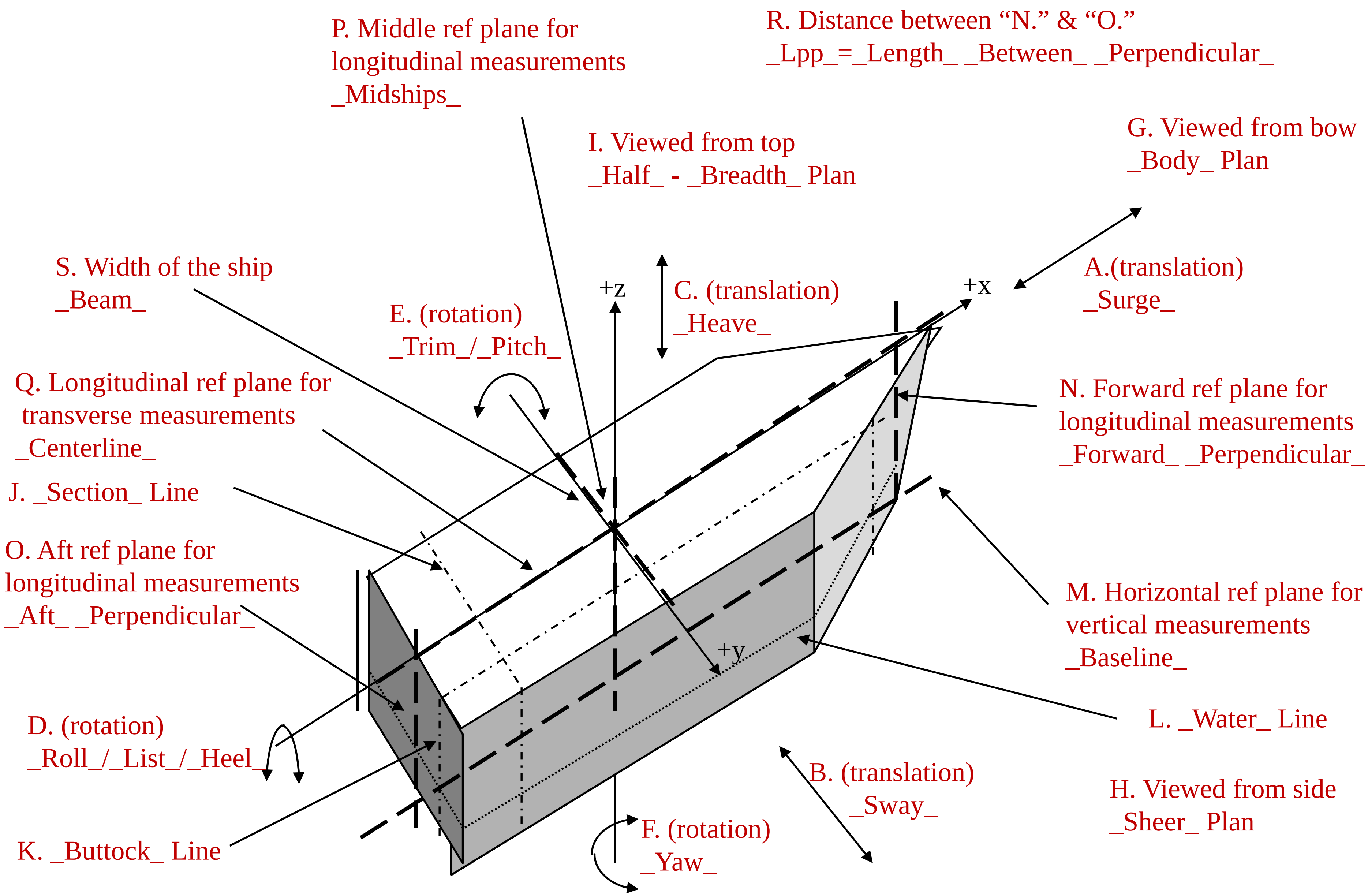
(b) Depth

(c) Draft

(d) Beam

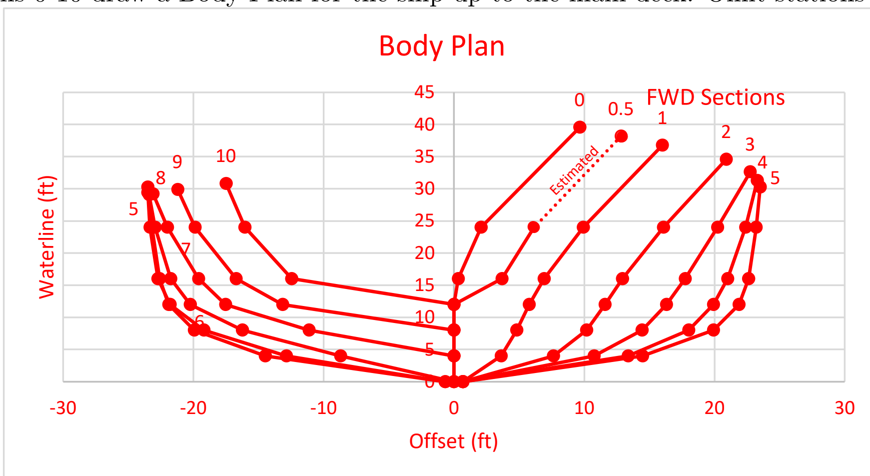
(e) Freeboard



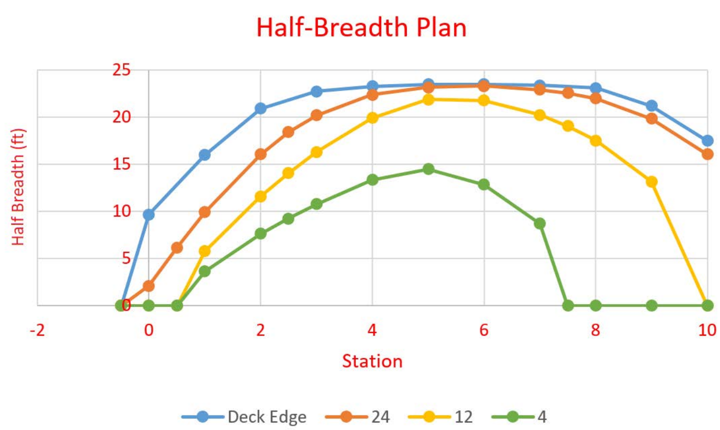

P. Middle ref plane for
longitudinal measurements
Midships
R. Distance between “N.” & “O.”
Lpp=_Length_ _Between_ _Perpendicular_
I. Viewed from top
Half - _Breadth_ Plan
G. Viewed from bow
Body Plan
S. Width of the ship
Beam
+z
C. (translation)
Heave
+x
A.(translation)
Surge
E. (rotation)
Trim/_Pitch_
Q. Longitudinal ref plane for
transverse measurements
Centerline
N. Forward ref plane for
longitudinal measurements
Forward _Perpendicular_
J. _Section_ Line
O. Aft ref plane for
longitudinal measurements
Aft _Perpendicular_
M. Horizontal ref plane for
vertical measurements
Baseline
+y
D. (rotation)
Roll/_List_/_Heel_
L. _Water_ Line
B. (translation)
Sway
H. Viewed from side
Sheer Plan
F. (rotation)
Yaw
K. _Buttock_ Line

2-7 For this question, use a full sheet of graph paper for each drawing. Choose a scale that gives the best representation of the ship's lines. Use the FFG-7 Table of Offsets given on the following page for your drawings.

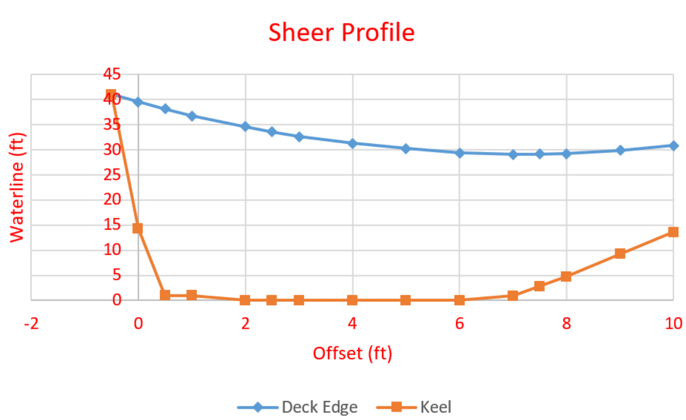
(a) For stations 0-10 draw a Body Plan for the ship up to the main deck. Omit stations 2.5 and 7.5.



(b) Draw a half-breadth plan showing the 4 ft, 12 ft, 24 ft waterlines, and the deck edge.

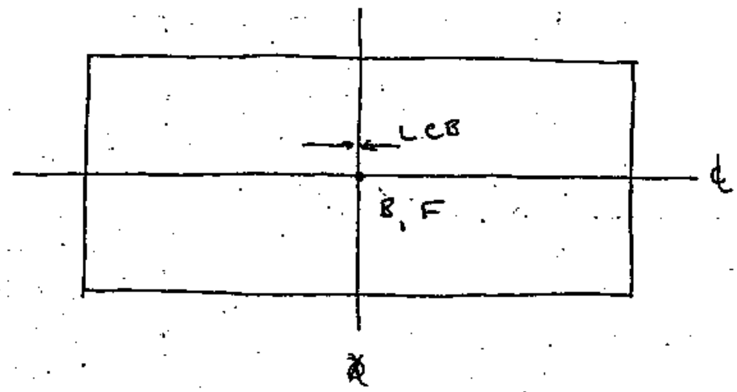


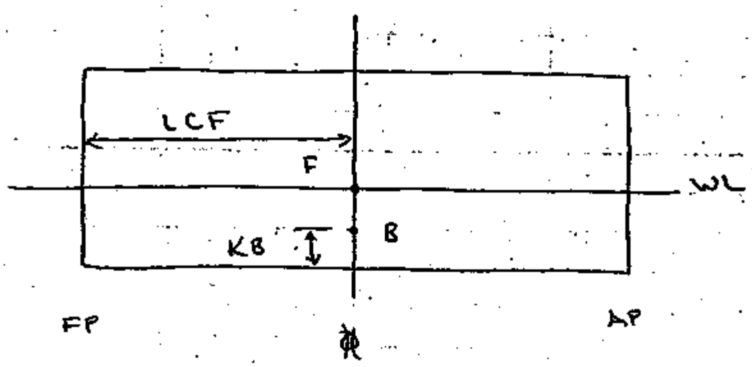
(c) Draw the sheer profile of the ship.

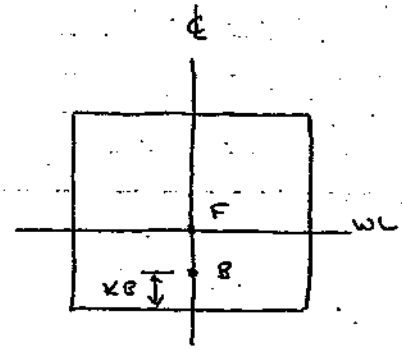


Box - shaped barge has L = 100 ft, B = 40 ft, Depth = 25 ft.
Current draft, T = 10 ft.

a, b. Draw waterplane, profile, and end view of barge.
Indicate ℄, WL, ⊗, B, and F. Also show KB, LCF, LC







c. Determine the following dimensions:

$KB = \frac{T}{2} = \frac{10\text{ ft}}{2} = 5\text{ ft}$

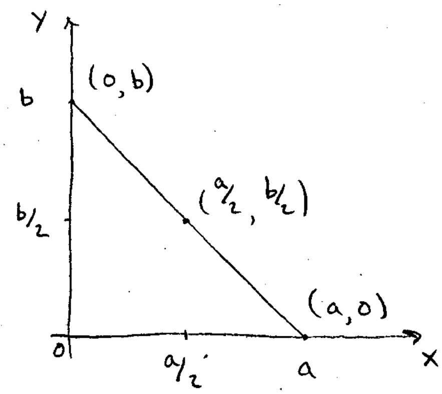
LCF from ⊗: LCF = 0 ft from ⊗

LCB from FP: LCB = 50 ft aft FP

Height of F above the keel = 10 ft

Use Simpson's Rule to calculate the following:

a) Right triangle with base of "a" and height "b"



$$A = \frac{\Delta x}{3}\left[1 y_0 + 4 y_1 + 1 y_2\right]$$

$\Delta x = a/2$ $\quad y_0 = b \quad y_1 = b/2 \quad y_3 = 0.$

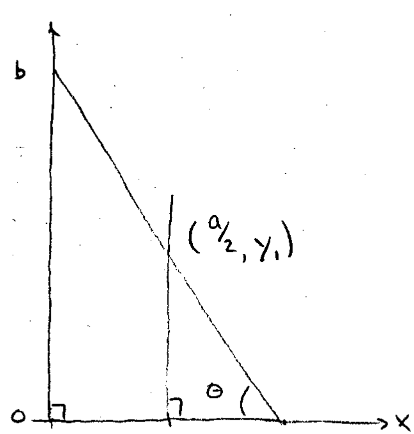
$$A = \left(\frac{1}{3}\right)\left(\frac{a}{2}\right)\left[1(b) + 4\left(\frac{b}{2}\right) + 1(0)\right]$$

$$= \frac{a}{6}\left[b + 2b\right]$$

$$= \left(\frac{a}{6}\right)(3b)$$

$$A = \frac{3ab}{6} = \boxed{\frac{ab}{2}}$$

Note: for any right triangle, $y\left(x = \frac{a}{2}\right) = \frac{b}{2}$



consider triangle $\Delta\left(\frac{a}{2}\ a\ y_1\right)$

$$\tan\theta = \frac{opp}{adj} = \frac{y_1}{a/2}$$

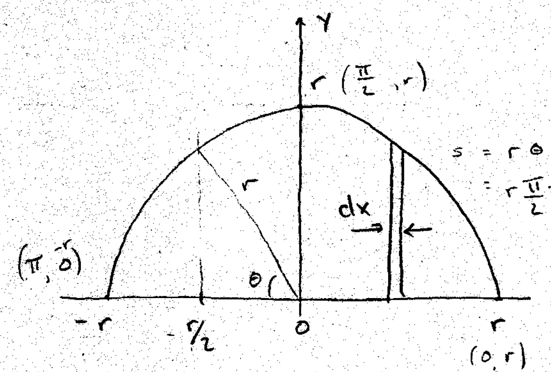
$$y_1 = \frac{a}{2}\tan\theta$$

but, $\tan\theta = \frac{b}{a}$

$$y_1 = \left(\frac{a}{2}\right)\left(\frac{b}{a}\right)$$

$$\therefore\ y_1 = \frac{b}{2}$$

b) Semi-circle of radius "r"



$$A = \int_{-r}^{r} y(x)\,dx$$

$$A = \frac{\Delta x}{3}\left[1y_0 + 4y_1 + 1y_2\right]$$

$\Delta x = r$

$y_0 = 0, \quad y_1 = r, \quad y_2 = 0$

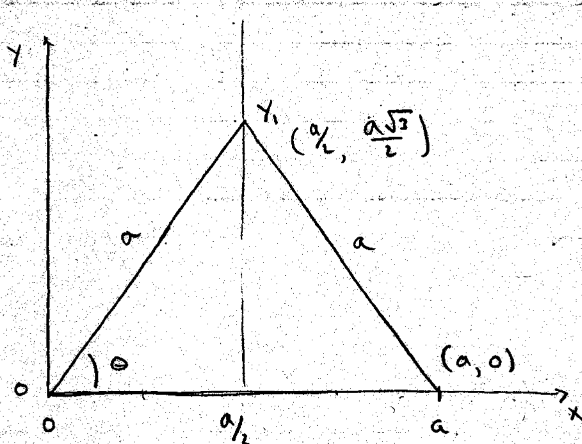
$$A = \frac{r}{3}\left[0 + 4r + 0\right]$$

$$= \frac{r}{3}(4r)$$

$$\boxed{A = \frac{4r^2}{3}}$$

actual is: $\frac{\pi r^2}{2}$

c) Equilateral triangle with each side having length "a"



for equilateral Δ, $\theta = 60°$

or, $\tan\theta = \frac{y_1}{a/2}$

$y_1 = \frac{a}{2}\tan\theta = \frac{a}{2}\tan$

$\tan 60° = \sqrt{3}$

$y_1 = \frac{a}{2}(\sqrt{3}) = \frac{a\sqrt{3}}{2}$

$$A = \frac{\Delta x}{3}\left[1y_0 + 4y_1 + 1y_2\right]$$

$\Delta x = \frac{a}{2}, \quad y_0 = 0, \quad y_1 = \frac{a\sqrt{3}}{2} \quad y_2 = 0$

$$A = \left(\frac{1}{3}\right)\left(\frac{a}{2}\right)\left[0 + 4\left(\frac{a\sqrt{3}}{2}\right) + 0\right]$$

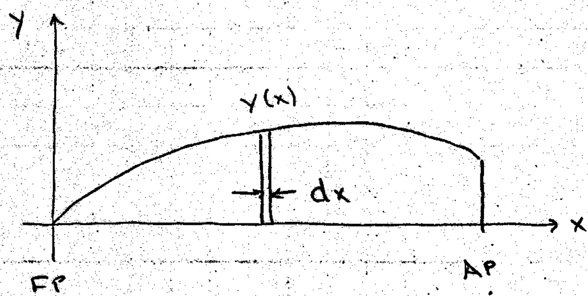
$$= \frac{a}{6}\left(2a\sqrt{3}\right)$$

$$\boxed{A = \frac{a^2\sqrt{3}}{3}}$$

Note: if 5 divisions are used get

Calculate A_{wp} at DWL and compare to actual result.

Use stations 0, 2.5, 5, 7.5, 10



$$A_{wp} = 2\int_{FP}^{AP} y(x)\,dx$$

$$= 2\left(\frac{\Delta x}{3}\right)\left[1y_0 + 4y_{2.5} + 2y_5 + 4y_{7.5} + y_{10}\right]$$

$$\Delta x = \frac{L_{PP}}{n-1} = \frac{408\text{ ft}}{5-1} = 102\text{ ft}$$

$$A_{wp} = \left(\tfrac{2}{3}\right)(102\text{ ft})\left[1(.33\text{ ft}) + 4(15.52\text{ ft}) + 2(22.61\text{ ft}) + 4(20.82\text{ ft}) + 1\right.$$

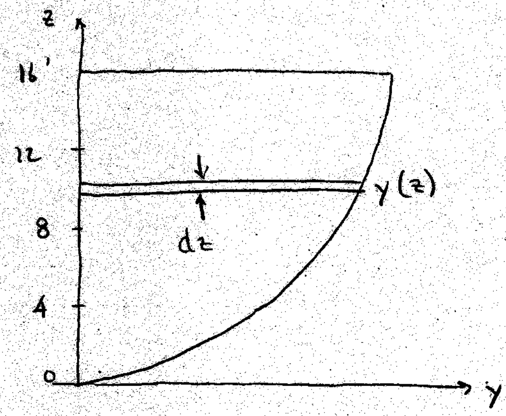
$$A_{wp} = \left(\tfrac{2}{3}\right)(102\text{ ft})(203.37\text{ ft})$$

$$\boxed{A_{wp} = 13829.2\text{ ft}^2}$$

Using 5 stations produces A_{wp} being slightly greater than actual. Increasing number of stations improves accuracy.

error $\approx$ .02 %

Using FFG-7 table of offset, calculate area of Station 3 up to DWL



$$A = 2\int_{K}^{DWL} y(z)\, dz$$

$$= 2\left(\frac{\Delta z}{3}\right)\left[1 y_0 + 4 y_4 + 2 y_8 + 4 y_{12} + y_{16}\right]$$

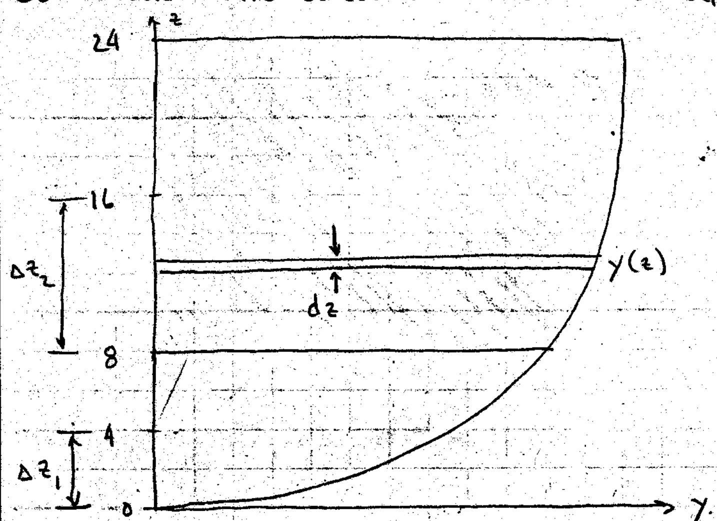
$$\Delta z = 4 \text{ ft}$$

$$A = 2\left(\frac{4 \text{ ft}}{3}\right)\left[.68 \text{ ft} + 4(10.77 \text{ ft}) + 2(14.43 \text{ ft}) + 4(16.31 \text{ ft}) + 17.75 \text{ f}\right.$$

$$= \left(\frac{8 \text{ ft}}{3}\right)(155.61 \text{ ft})$$

$$\boxed{A = 414.96 \text{ ft}^2}$$

Calculate the area of Station 6 up to the 24 ft WL.



$$A_6 = 2\int_K^{24} y(z)\,dz = 2\int_0^8 y(z)\,dz + 2\int_8^{24} y(z)\,dz$$

$$= 2\left(\frac{\Delta z_1}{3}\right)\left[1y_0 + 4y_4 + 1y_8\right] + 2\left(\frac{\Delta z_2}{3}\right)\left[1y_8 + 4y_{16} + 1y_{24}\right]$$

$\Delta z_1 = 4$ ft $\qquad \Delta z_2 = 8$ ft

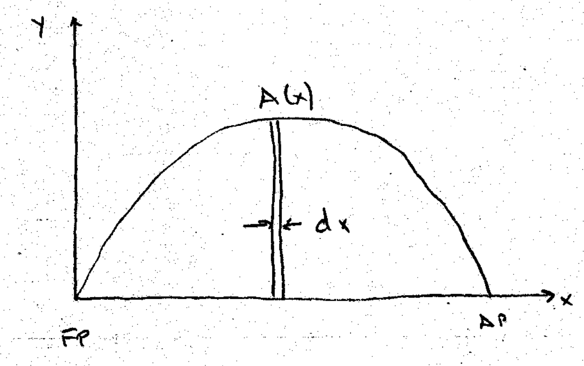
$$= 2\left(\frac{4\text{ ft}}{3}\right)\left[.68\text{ ft} + 4(12.86\text{ ft}) + (19.21\text{ ft})\right] + 2\left(\frac{8\text{ ft}}{3}\right)\left[19.21\text{ ft} + 4(22.74\text{ ft}) + 23.33\text{ ft}\right]$$

$$= \left(\frac{8\text{ ft}}{3}\right)(71.33\text{ ft}) + \left(\frac{16\text{ ft}}{3}\right)(133.5\text{ ft})$$

$$A_6 = 190.21\text{ ft}^2 + 712\text{ ft}^2$$

$$\boxed{A_6 = 902.2\text{ ft}^2}$$

Using sectional areas for station 0, 2.5, 5, 7.5, 10, calculate the submerged volume and displacement to the DWL.



$$\nabla = \int_{FP}^{AP} A(x)\,dx$$

$$\nabla = \frac{\Delta x}{3}\left[1A_0 + 4A_{2.5} + 2A_5 + 4A_{7.5} + A_{10}\right]$$

$$\Delta x = \frac{L_{PP}}{n-1} = \frac{408\text{ ft}}{5-1} = 102\text{ ft}$$

$$\nabla = \left(\frac{102\text{ ft}}{3}\right)\left[.88\text{ ft}^2 + 4(357.9\text{ ft}^2) + 2(556.3\text{ ft}^2) + 4(334.1\text{ ft}^2) + 33.22\text{ f}\right.$$

$$\nabla = \left(\frac{102\text{ ft}}{3}\right)(3914.7\text{ ft}^2)$$

$$\boxed{\nabla = 133099.8\text{ ft}^3}$$

Displacement in salt water

$$\Delta_{SW} = \rho_{SW}\, g\, \nabla$$

$$= \left(1.99\ \frac{\text{lb s}^2}{\text{ft}^4}\right)\left(32.17\ \text{ft}/\text{s}^2\right)\left(133099.8\text{ ft}^3\right)\left(\frac{\text{LT}}{2240\text{ lb}}\right)$$

$$\boxed{\Delta_{SW} = 3804\text{ LT}}$$

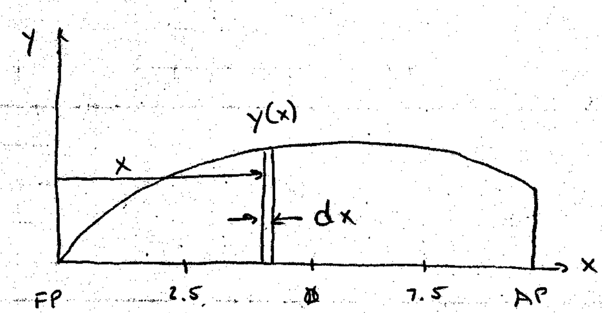
Displacement in fresh water

$$\Delta_{FW} = \rho_{FW}\, g\, \nabla$$

$$= \left(1.94\ \frac{\text{lb s}^2}{\text{ft}^4}\right)\left(32.17\ \frac{\text{ft}}{\text{s}^2}\right)\left(133099.8\text{ ft}^3\right)\left(\frac{\text{LT}}{2240\text{ lb}}\right)$$

$$\boxed{\Delta_{FW} = 3708\text{ LT}}$$

Determine LCF at DWL referenced to ⊗.



Find LCF from FP:

$$LCF_{FP} = \frac{2\int_{FP}^{AP} x\,y(x)\,dx}{A_{wp}}$$

$$= \frac{2\,\Delta x}{3\,A_{wp}}\left[1 x_0 y_0 + 4 x_{2.5} y_{2.5} + 2 x_5 y_5 + 4 x_{7.5} y_{7.5} + 1 x_{10} y_{10}\right]$$

$$\Delta x = \frac{L_{pp}}{n-1} = \frac{408 \text{ ft}}{5-1} = 102 \text{ ft} \qquad A_{wp} = 13826.0 \text{ ft}^2$$

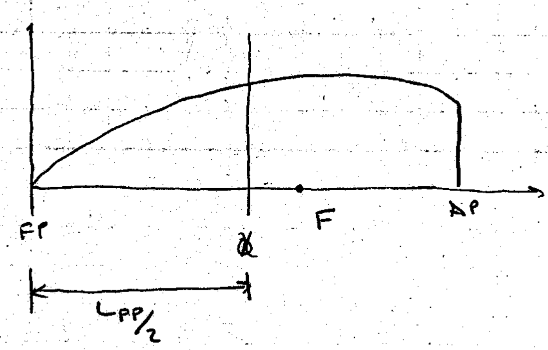
Stn	y (ft)	x (ft)	Simp	(Simp)(x)(y) (ft^2)
0	0.33	0	1	0
2.5	15.52	102	4	6332.16
5	22.61	204	2	9224.88
7.5	20.82	306	4	25483.7
10	12.46	408	1	5083.68

$\Sigma = 46124.4 \text{ ft}^2$

$$LCF_{FP} = \frac{(2)(102 \text{ ft})}{(3)(13826 \text{ ft}^2)}\left(46124.4 \text{ ft}^2\right)$$

$LCF_{FP} = 226.9$ ft aft FP

Reference from ⊗



$$LCF_{⊗} = \frac{L_{pp}}{2} - LCF_{FP}$$

$$= \frac{408 \text{ ft}}{2} - 226.9 \text{ ft}$$

15)

What 2 assumptions are made when computing a ships hydrostatic parameters in the curves of form?

- ship floating on an even keel (zero list, zero trim).
- salt water at 59° F

16)

FFG-7 floating on even keel at draft of 14 ft. Use Curves of Form to find the following:

Parameter = (General Scale)(Scale Factor)

a. displacement: $\Delta = (108)(30\ LT) = 3240\ LT$

b. LCF: LCF = 22 ft aft ⊗ (top scale)

c. KB: $KB = (44)(.2\ ft) = 8.8\ ft$

d. TPI: $TPI = (158)(.2\ LT/in) = 31.6\ LT/in$

e. MT1": $MT1" = (125)(5.78\ ft\cdot LT/in) = 722.5\ ft\cdot LT/in$

f. ∇: $\Delta = \rho g \nabla$

$$\nabla = \frac{\Delta}{\rho g} = \frac{(3240\ LT)(2240\ lb)}{(1.99\ \frac{lb\,s^2}{ft^4})(32.17\ ft/s^2)\ LT}$$

$$\boxed{\nabla = 113367.6\ ft^3}$$

17)

FFG-7 floating with forward draft = 14.9 ft and aft draft = 15.
Use curves of form to find:

→ enter curves using mean draft

$$T_m = \frac{T_f + T_a}{2} = \frac{14.9\text{ ft} + 15.5\text{ ft}}{2} = 15.2\text{ ft}$$

a) Δ : $\Delta = (123)(30\text{ LT}) = 3690\text{ LT}$

b) LCF : LCF = 24 ft aft ~~⊗~~

c) MT1" : $MT1" = (131)(5.78\ \text{LT}\cdot\text{ft/in}) = 757.2\ \text{LT}\cdot\text{ft/in}$

18)

FFG in problem 15 changes draft to 15.5 ft.

What is new TPI? $TPI_{15} = (162)(.2\ \text{LT/in}) = 32.4\ \text{LT/in}$

Why does TPI change?

TPI is a function of waterplane area. As draft changes Awp changes. Therefore TPI changes.

19)

DDG-51 floating on even keel at draft of 21.5 ft. 150 LT piece of machinery is added.

a. Where must 150 LT be added so that trim doesn't change?

At Center of Flotation

b. What is change in draft due to weight addition?

$$\delta T = \frac{w}{TPI}$$

$$TPI = (173)(.3\ LT/in) = 51.9\ LT/in$$

$$\delta T = \frac{150\ LT}{51.9\ LT/in}$$

$$\boxed{\delta T = 2.89\ in}$$

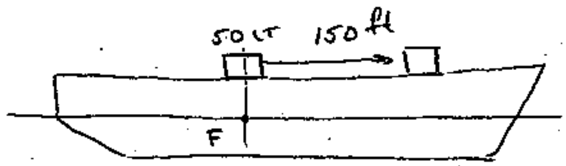
c. What is new draft?

$$T_{new} = T_{old} + \delta T = 21.5\ ft + \frac{2.89\ in}{12\ in/ft} = \boxed{21.74\ ft}$$

20)

DDG-51 floating on even keel at draft of 21.5 ft. 50 LT is moved from center of flotation to a point 150 ft forward of F.

Calculate the change in trim.



$$\delta Trim = \frac{wl}{MT1''}$$

$$MT1'' = (163)(9.24\ LT\cdot ft/in) = 1506.12\ LT\cdot ft/in$$

$$\delta Trim = \frac{(50\ LT)(150\ ft)}{1506\ LT\cdot ft/in} = \boxed{4.98\ in} = \boxed{.42\ ft}$$