Small boat characteristics

$\Delta = 40$ LT

$\nabla = 875\ ft^3$

speed = 20 kt

a. Magnitude of hydrostatic support:

Hydrostatic support = F_B buoyant force

$$F_B = \rho g \nabla$$

$$= \left(1.99 \frac{lb\, s^2}{ft^4}\right)\left(32.17 \frac{ft}{s^2}\right)\left(875\ ft^3\right)$$

$$= 56016\ lb$$

$$F_B = (56016\ lb)\left(\frac{LT}{2240\ lb}\right)$$

$\therefore F_B = 25$ LT $\rightarrow$ Hydrostatic support is only 25 LT

b. Boat is also receiving hydrodynamic support based upon its speed through the water and resultant hydrodynamic force acting on the hull of the boat.

To keep the boat floating,

$F_B + F_D = \Delta$, F_B = buoyant force, F_D = dynamic force

c. $F_D = \Delta - F_B = 40\ LT - 25\ LT = 15\ LT$

Other physical note, at 20 kts, the displaced volume of the hull is only a fraction of the total volume displaced for a 40 LT boat sitting at rest.

d. If the boat slows to 5 kts the amount of hydrodynamic force acting on the hull will decrease. The boat's displaced volume will increase and the hydrostatic force (buoyant force) will increase.

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

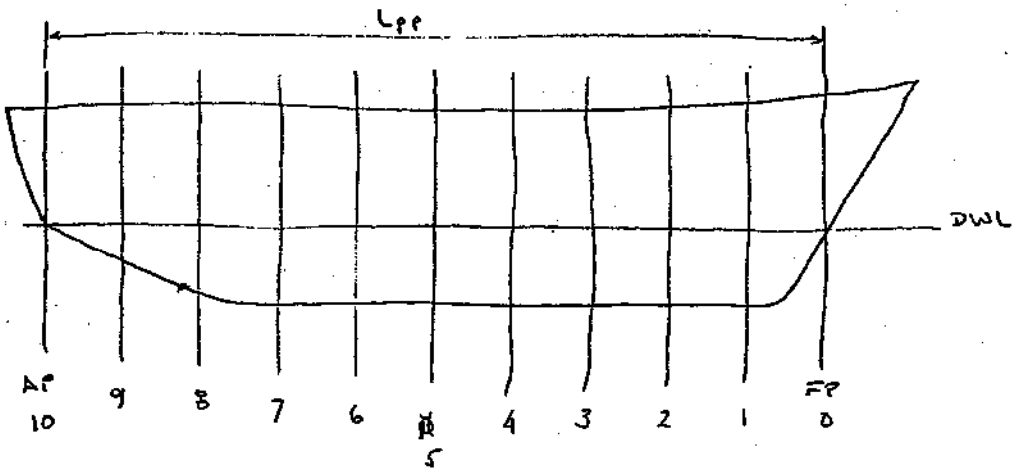
3. a. SWATH = Small Waterplane Area Twin Hull

b. Supported by hydrostatic forces while underway.

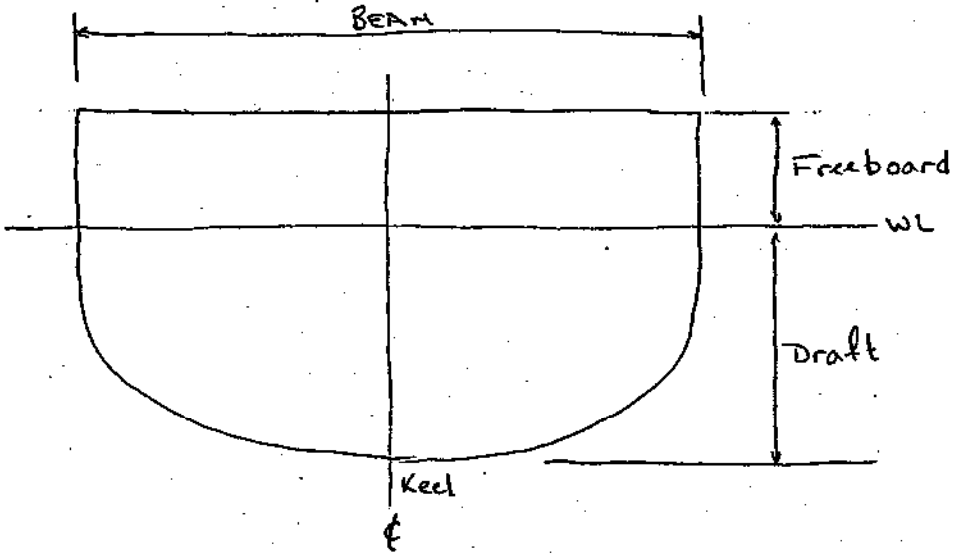
c. Advantages of SWATH :

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

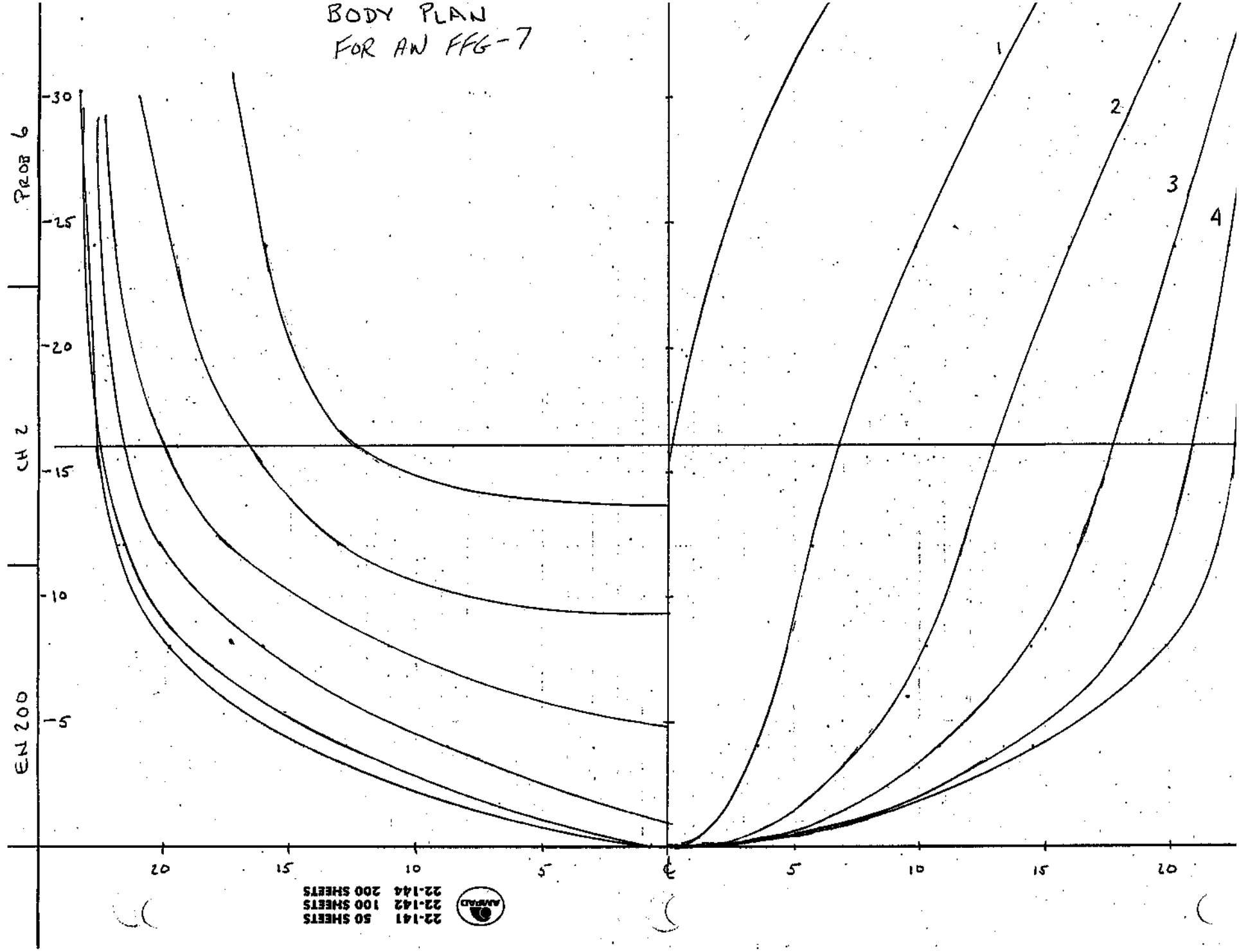
(4)



(5) Sketch a section of a ship and show various elements

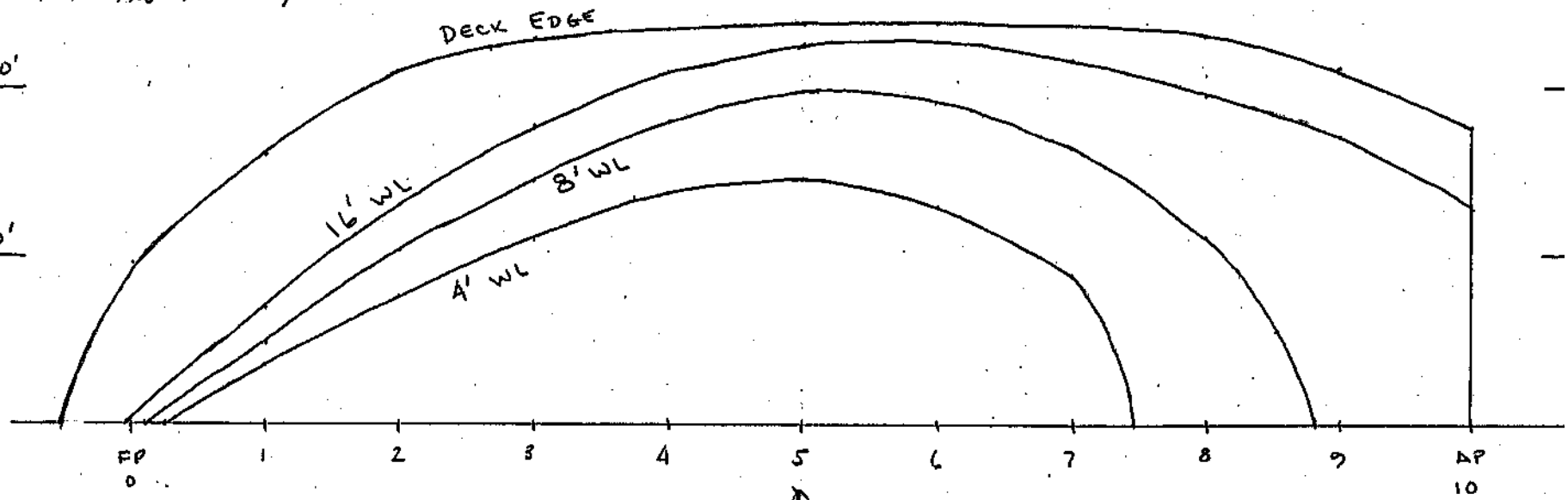


BODY PLAN
FOR AN FFG-7

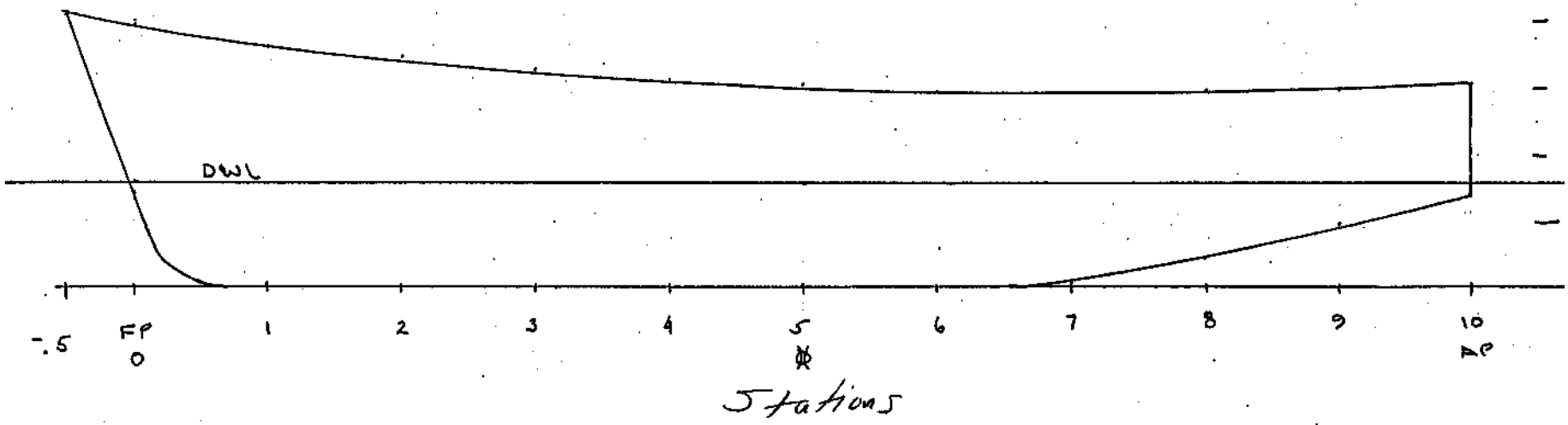


AMPAD
22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS

HALF-BREADTH PLAN
FOR AN FFG-7



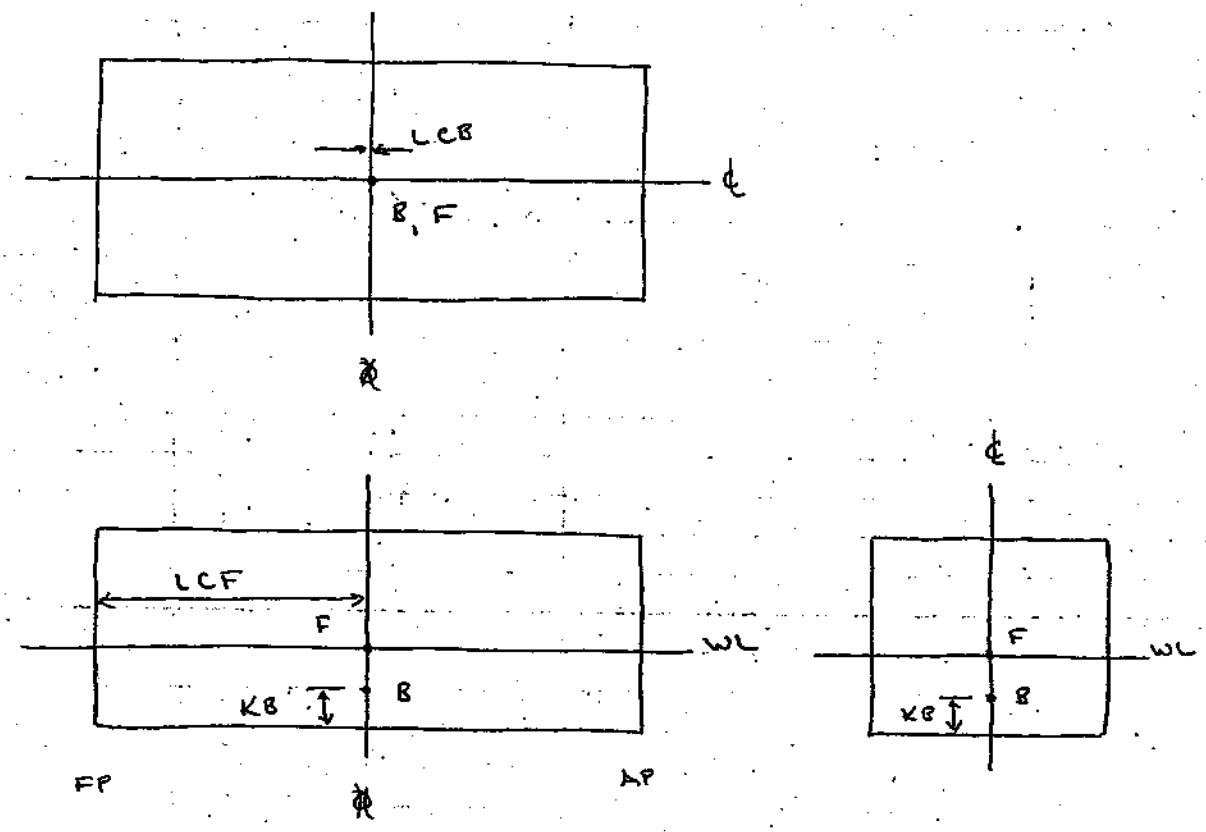
SHEER PLAN FOR
AN FFG-7



PROB 6
CH 2
EN 200
AMPAD 22-141 50 SHEETS 22-142 100 SHEETS 22-144 200 SHEETS

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:

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

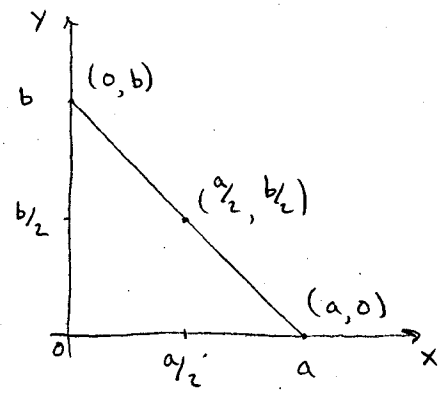
LCF from ⊗: LCF = 0 ft from ⊗

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"



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

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

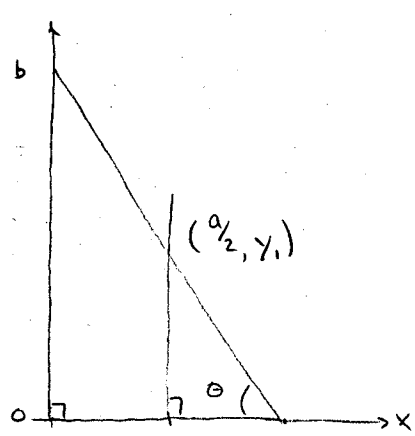
$$A = \left(\frac{1}{3}\right)\left(\frac{a}{2}\right)\left[1(b) + 4\left(\frac{b}{2}\right) + 1(0)\right]$$

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

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

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

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



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

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

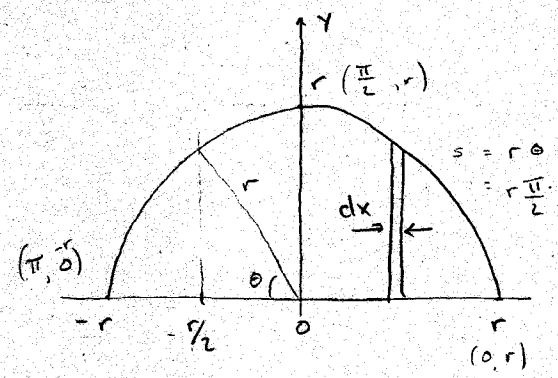
$$y_1 = \frac{a}{2}\tan\theta$$

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"



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

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

$\Delta x = r$

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

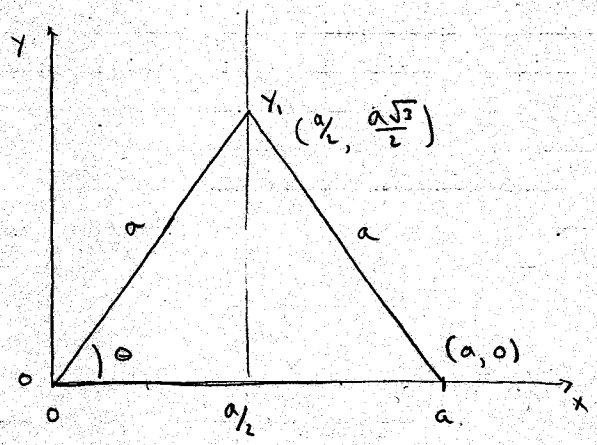
$$A = \frac{r}{3}\left[0 + 4r + 0\right]$$

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

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

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

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



for equilateral Δ, $\theta = 60°$

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

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

$\tan 60° = \sqrt{3}$

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

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

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

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

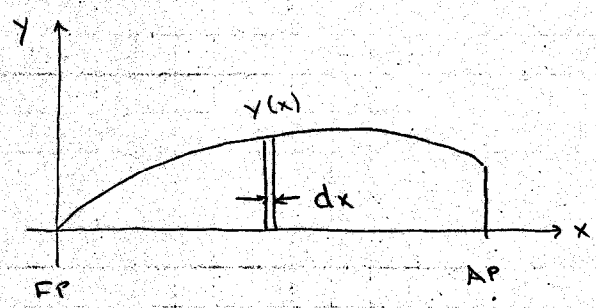
$$= \frac{a}{6}\left(2a\sqrt{3}\right)$$

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

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



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

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

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

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

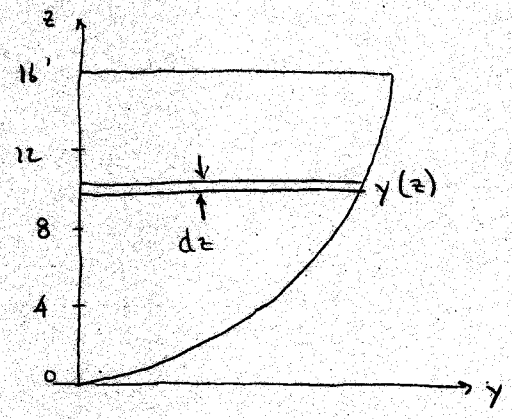
$$A_{wp} = \left(\tfrac{2}{3}\right)(102\text{ ft})(203.37\text{ ft})$$

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

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 offsets, calculate area of Station 3 up to DWL



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

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

$$\Delta z = 4\ ft$$

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

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

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

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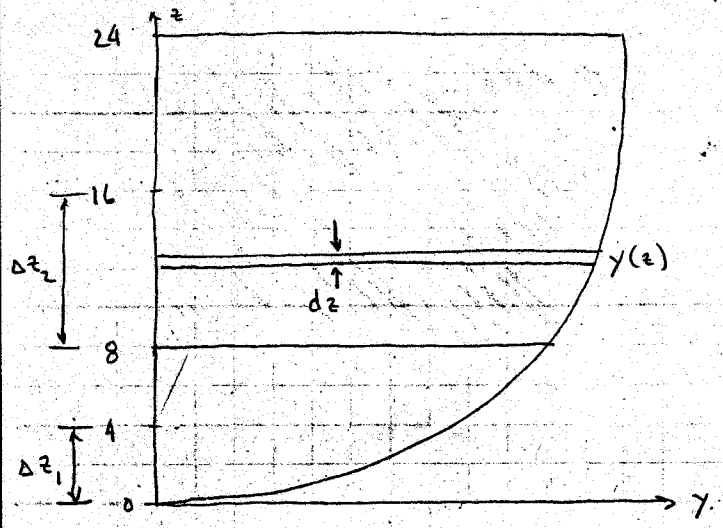
AMPAD

Calculate the area of Station 6 up to the 24 ft w.l.



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

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

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

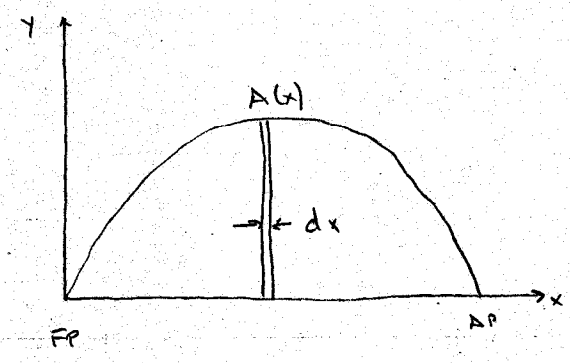
$$= 2\left(\frac{4\text{ ft}}{3}\right)\left[.68\text{ ft} + 4(12.86\text{ ft}) + (19.21\text{ ft})\right]$$
$$+ 2\left(\frac{8\text{ ft}}{3}\right)\left[19.21\text{ ft} + 4(22.74\text{ ft}) + 23.33\text{ ft}\right]$$

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

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

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

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

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

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

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

Displacement in fresh water

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

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

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

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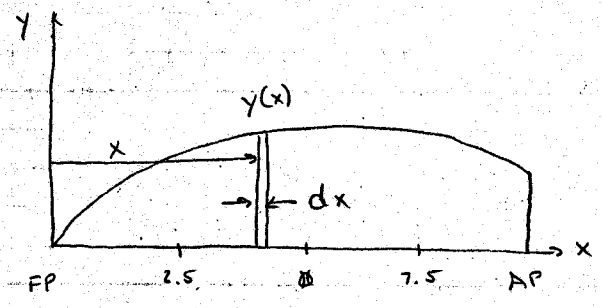
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

Determine LCF at DWL referenced to ⊗.



Find LCF from FP:

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

$$= \frac{2\,\Delta x}{3\,A_{WP}}\left[1x_0y_0 + 4x_{2.5}y_{2.5} + 2x_5y_5 + 4x_{7.5}y_{7.5} + 1x_{10}y_{10}\right]$$

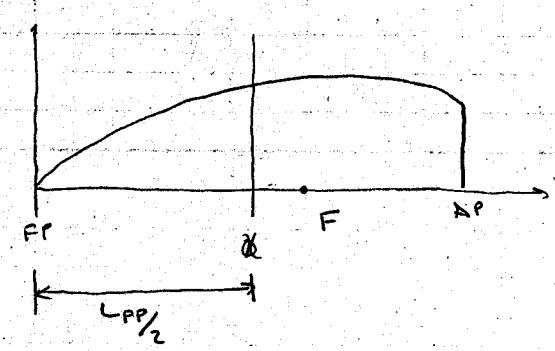
$$\Delta x = \frac{L_{PP}}{n-1} = \frac{408\text{ ft}}{5-1} = 102\text{ ft} \qquad A_{WP} = 13826.0\text{ ft}^2$$

Stn	y (ft)	x (ft)	Simp	(Simp)(x)(y) (ft²)
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

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

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

$$LCF_{FP} = 226.9\text{ ft aft FP}$$



Reference from ⊗

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

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

14) What 2 assumptions are made when computing a ship's hydrostatic parameters in the curves of form?

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

15) 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. ∇: $\Delta = \rho g \nabla$

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

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

16) 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: Δ = (123)(30 LT) = 3690 LT

b) LCF: LCF = 24 ft aft

c) MT1": MT1" = (131)(5.78 LT·ft/in) = 757.2 LT·ft/in

17) FFG in problem 15 changes draft to 15.5 ft.

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

Why does TPI change?

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

18) 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?

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

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

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

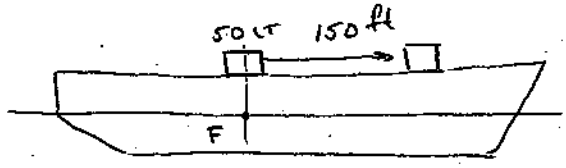
$$\boxed{\delta T = 2.89\ in}$$

c. What is new draft?

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

19) 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.



$$\delta Trim = \frac{wl}{MTI^{"}}$$

$$MTI^{"} = (163)(9.24\ LT\cdot ft/in) = 1506.12\ LT\cdot ft/in$$

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