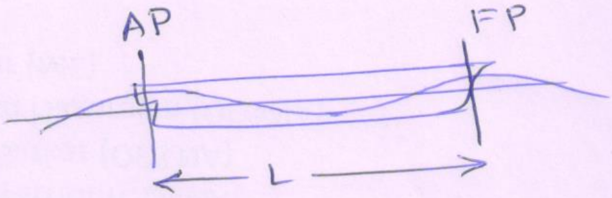
(weight − buoyancy) is important for longitudinal bending.

Typical heave/roll frequency around 0·1 Hz.
Hull structural frequency around 1 Hz.
Local structural frequency around 100 − 300 Hz.

What is water tight? weather tight?



Wave hydrodynamics $\omega^2 = gk \tanh kd$

for deep water, $L = 1{\cdot}56\,T^2$, $(T = 2\pi/\omega)$

$\therefore$ for LPP $\approx$ 150 m, $T \approx 10$ sec.

for $L \leqslant 150$ m, L/H may be around 20. (i.e., $H = \frac{L}{20}$)

$L > 150$ m, H may be taken as $0{\cdot}607\sqrt{L}$ or $1{\cdot}632L^{0{\cdot}3}$

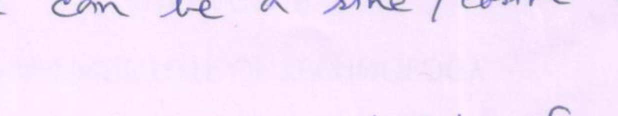
* Refer recommended practice/client's document/standard etc.

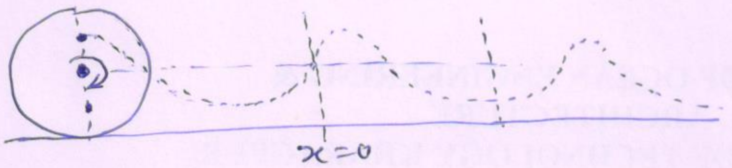
Waves break beyond certain height, for deep water $H/L \ngtr 0{\cdot}142$

finite water depth $0{\cdot}142\tanh(kd)$

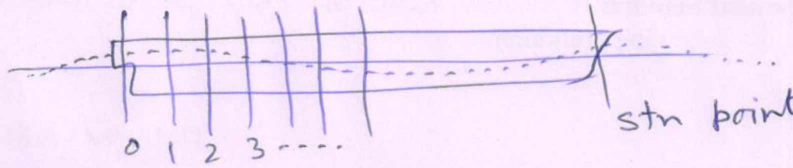
Shape of the wave can be a sine/cosine curve or a trochoid.

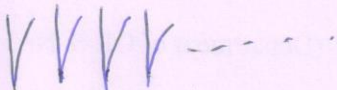
In shallow water, wave shape deviates from a sine curve, crest becomes higher and sharper, trough becomes shallower and flatter.





For most cases, sine curve is enough.





Superimpose water surface profile on Bonjean's curves to obtain buoyancy variation.

Weight Distribution for various conditions must be considered in design.

Fully loaded departure (heaviest)
" " arrival
Partly " departure
" " arrival
Ballast departure
" arrival (lightest)

Why a ship is ballasted after offloading its cargo?
(Zone of blindness)

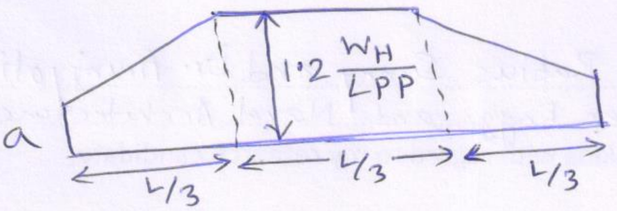
For a ship,

Total weight
- light weight — ship ready to go without consumables
  - Hull weight (continuous)
  - machineries and equipments } semi-continuous
  - accommodation, fittings }
- Dead weight
  - cargo
  - fuel and oil
  - fresh water
  - ballast

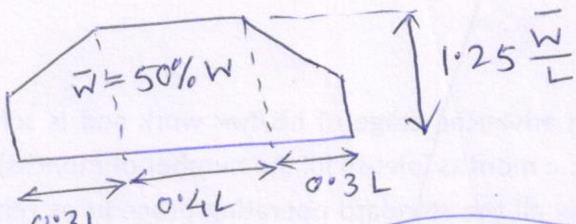
Total weight = displacement

Hull weight of ships having parallel middle body ($L/3$) is sometime taken as:— Biles method

W_H = weight of hull

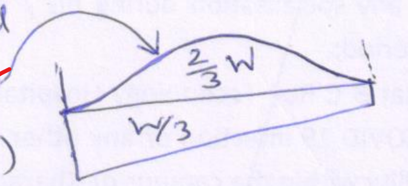


Comstock

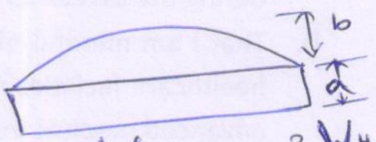


For fast moving vessels,

Huge's method (Still water buoyancy curve)



Cole's method



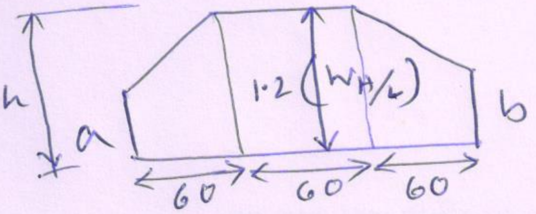
$a = \frac{W_H}{2L}$, $b = \frac{3}{4}\frac{W_H}{L}$

\# go through the problem solved on Bile's method.

\# "Methods of determining the longitudinal weight distribution of a ship", presentation by SNAME and Society of Allied Weight Engineers.

The total weight of a ship = 54000 Te., LCG 1·0 m aft. of ⊗. A 3000 Te weight crane is located at 1·2 m forward of ⊗. Find the weight distribution assuming that the ship is having parallel middle body of $L/3$. ($L = 180$m)

Here, total weight = 54000 Te
crane = 3000 Te
∴ hull weight = 51000 Te



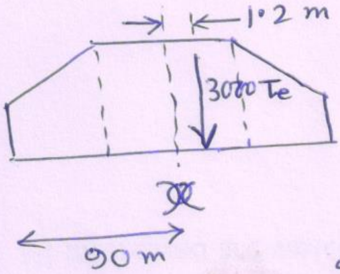
$W_H = 51000$ Te

$\therefore h = \dfrac{51000 \times 1.2}{180} = 340$ Te/m

$\therefore \frac{1}{2}(a+340)\,60 + \frac{1}{2}(b+340)\,60 + 340 \times 60 = 51000$

$a + 340 + b + 340 = 1020$

$\therefore \quad a + b = 340$ ——— (i)

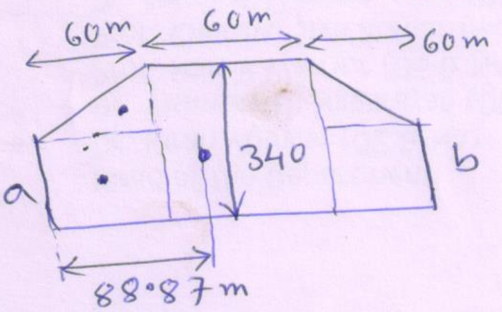


LCG = $\cancel{91.2\text{ m}}$ 1 m after x = 89 m

If LCG of hull (alone) $= x$, then

$$\frac{51000x + 3000 \times 91.2}{54000} = 89$$

$\therefore x = 88.87$ m



$$\left(a \times 60 \times \frac{60}{2}\right) + \left(\frac{1}{2} \times (340-a) \times 60 \times \frac{2}{3} \times 60\right) + 340 \times 60 \times \left(60 + \frac{60}{2}\right)$$
$$+ \left(b \times 60 \times \left(\frac{60}{2} + 60 \times 2\right)\right) + \frac{1}{2} \times (340-b) \times 60 \times \left(60 \times 2 + \frac{1}{3} \times 60\right)$$
$$= 51000 \times 88.87$$

$\Rightarrow \quad a + 8b = 1433.95$ ——— (ii)

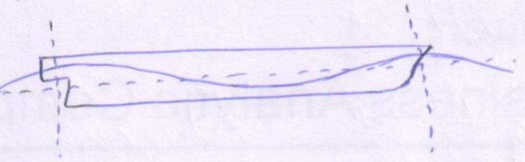
Solving (i) and (ii), we get $\quad a = 183.7$ T/m, $b = 156.28$ T/m

Why a returning ship is ballasted?
< propeller immersion 85%, zone of blindness 1-1.5×LOL >

Points to be considered in ship design
- least linear dimension (for registration fees etc.)
- least resistance for the specified speed
- minimum light weight
- minimum acquisition cost
- minimum upkeep cost / maintenance cost
- minimum breakdown
- maximum reliability
- maximum payload
- maximum profit

typical life of a ship - 20-25 years.

longitudinal bending in waves -



Bonjean's curves

(I) consider still water condition, (LCG given)

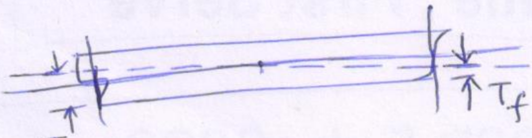
(II) Weight (W) = displacement (Δ) → find draft (T) (even keel draft)

(III) For that T, find LCB, LCF, TP1cm, MCT 1cm

(IV) calculate ~~parallel sinkage~~ trim = $\frac{\text{Trimming moment}}{\text{MCT 1cm}}$

Trimming moment = $\Delta(LCB \sim LCG)$

(V) calculate draft at perpendiculars (T_a, T_f)



(VI) Put new water line on cross-sectional area curve / Bonjean curve and calculate total buoyancy (Δ_N)

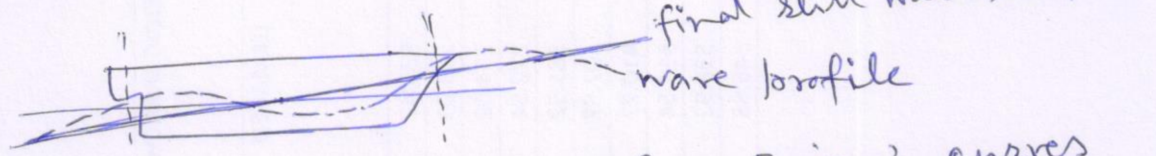
(VII) calculate parallel sinkage $= \dfrac{\Delta_N - W}{T_P\,1\,cm}$

This will give new values of draft (T)

(VIII) for this draft again find hydrostatic parameters (LCB, LCF, TP 1 cm, ~~TA~~ MCT 1 cm,

(IX) repeat calculation (iteration) until differences are small.

(X) After still water condition, wave profile may be considered.



calculate total buoyancy from Bonjean's curves

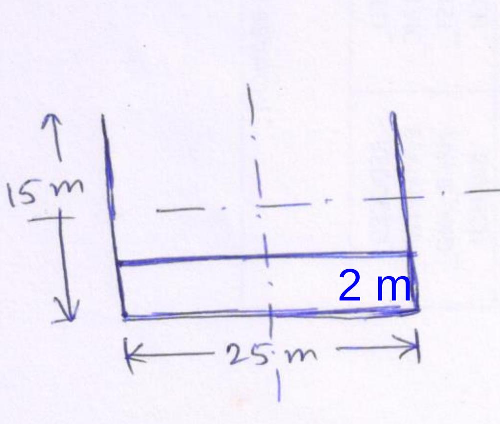
calculate parallel sinkage, new draft → LCB, LCF, TP, MCT

calculate trim and new drafts at perpendiculars

This can modify the wave profile

Repeat the above process untill the ~~new~~ differences are small.

You have already studied Marine Construction. Try to find out these items:- Keel plate, bottom plate, bilge plate, side plate, shear strake, inner margin, deck plate, inner bottom, tank top, center girder, side girder, bottom longitudinal, deck longitudinal, deck girder, inner bottom longitudinal



all plates are 16 mm thk.

Calculate the moment of inertia (MOI) of the section.

The total weight of a ship is 54000 Te (including an equipment of 3000 T placed at 1·2 m forward of midship and another of 2000 T placed at 3 m after mid-ship. The LPP = 180 m. LCG = 1 m after mid-ship. Assume parallel middle body and find out the longitudinal distribution of weight of the hull.