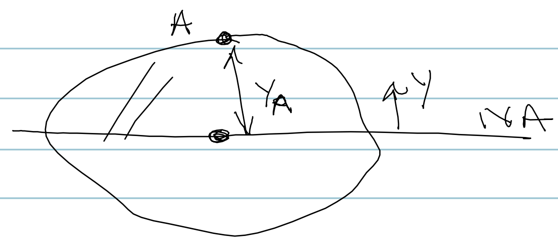
SECTION MODULUS Calculations

o $\sigma = \frac{My}{I}$ $\sigma_{max} = \frac{Mc}{I}$ $c = \max y$

$Z = I/c$ $Z_{DECK} = I/y_{deck}$

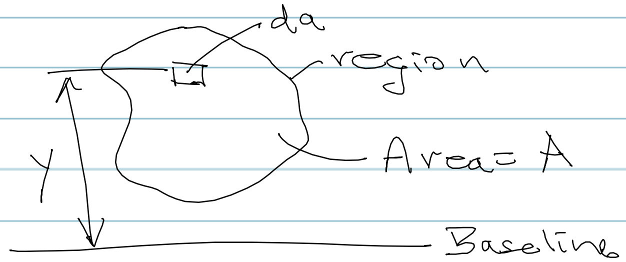
$Z_{Keel} = I/y_{Keel}$

$\sigma = \frac{M}{Z}$ $\sigma_{Deck} = \frac{M}{Z_{deck}}$ - .



$\sigma_A = M/Z_A = \frac{M y_A}{I_{NA}}$

Moments of Areas



$\int_{region} da = A = {}^0A$

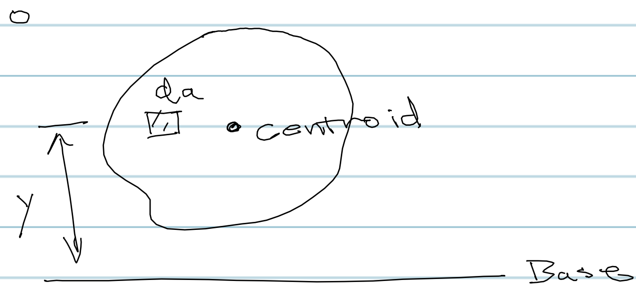
0th moment

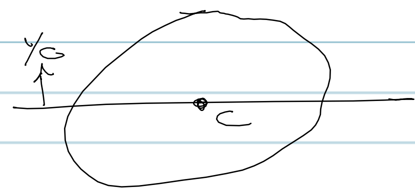
nth moment y $= \int y^n da$ ${}^nA$

$n=0$ $y^0 = 1$

$n=1$ $y^1 = y$ ${}^1A = \int_{region} y\, da$

$n=2$ y^2 ${}^2A = \int_{region} y^2 da = I_{Baseline}$

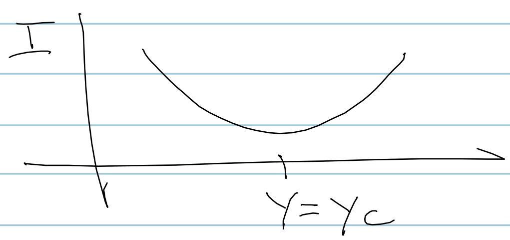


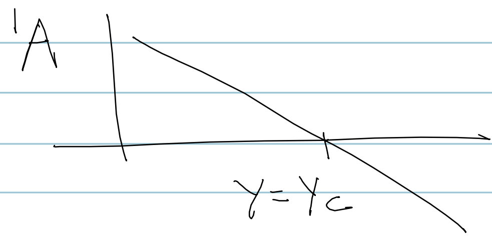


$'A = 0$

$\int y_c \, da = 0$

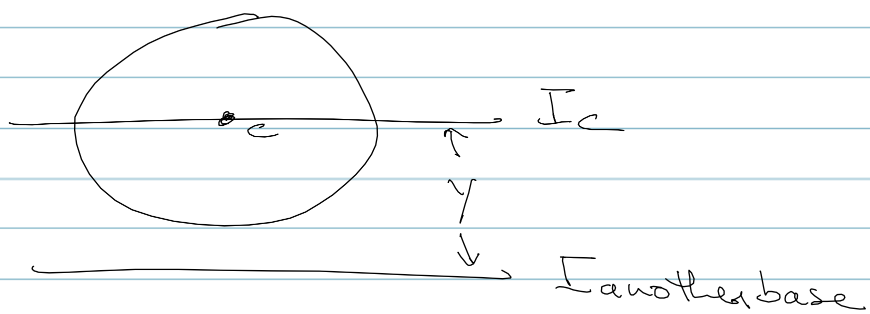
$I_c = I_{NA} = \int y_c^2 \, da$





Transfer of Axis

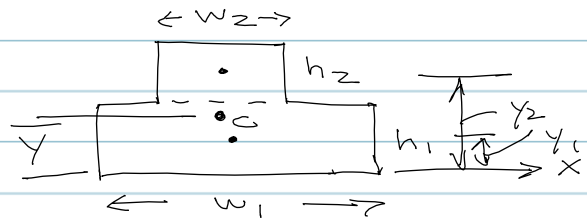
$I_c + Ay^2 = I_{\text{Another base}}$

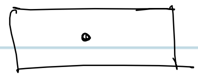


$I_c = I_{Base} - A y_{B \to c}^2$

- Compound Properties

Centroids





$y_1 = h_1/2 \qquad a_1 = w_1 h_1$

$y_2 = h_1 + h_2/2 \qquad a_2 = w_2 h_2$

$${}^1A = \int y_1\, da \Rightarrow \sum y a$$

$${}^0A = A = \sum_{i=1}^{n} a_i$$

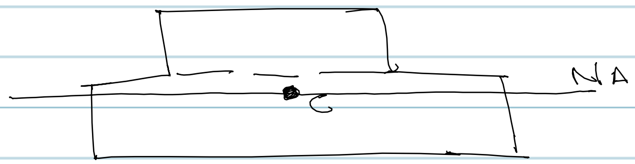
$$A = \sum a = w_1 h_1 + w_2 h_2$$

$$\sum y_i a_i = \bar{Y} \sum a_i$$

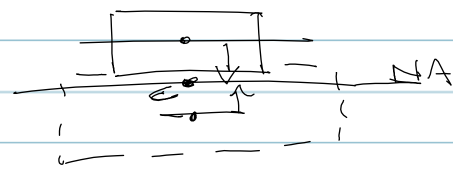
$$\bar{Y} = \frac{\sum y_i a_i}{A} \quad \left(= \frac{\sum y_i a_i}{\sum a_i} \right)$$

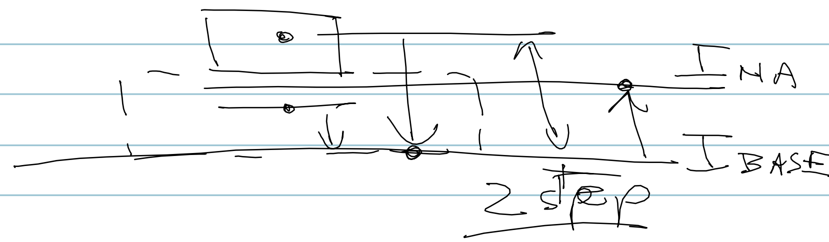
$$\bar{Y} = \frac{h_1/2\,(h_1 w_1) + (h_1 + h_2/2)(h_2 w_2)}{h_1 w_1 + h_2 w_2}$$

◦ Compound Moment of Inertia



2 ways





From local NA :

$$I_B = I_C + ad^2$$

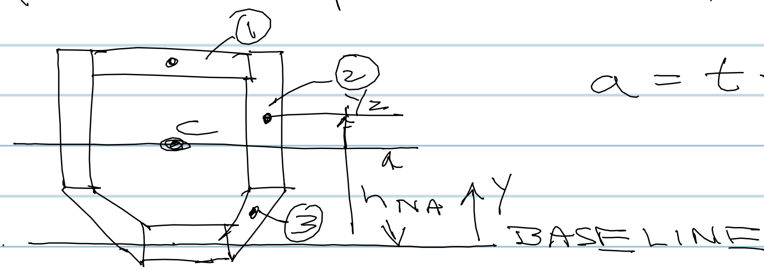
d : B ⟷ C

To NA (from other Base)

$$I_C = I_B - ad^2$$

$$I_{B1} \neq I_{B2} + ad^2$$

o Typical Calculation I_{NA} / location of cent. for a ship X-section



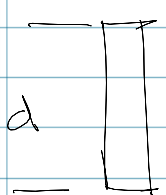
$a = t \cdot l$

TABLE FOR I

#	Name Item	a	y	ay	ay^2	i
1	Deck Pl.	$t \cdot l$	y_1	$a_1 y_1$	$a_1 y_1^2$	i_1
2	Side PL	a_2	y_2			i_2
3	Bilge PL	a_3	y_3			i_3
	⋮					

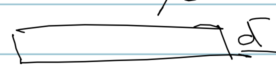
$\Sigma = A$ $\quad \Sigma ay \quad \Sigma ay^2 \quad \Sigma i$

$y_c = h_{NA} = \Sigma ay / \Sigma a$



$i = \frac{1}{12} t h^3$

$= \frac{1}{12} a h^2$



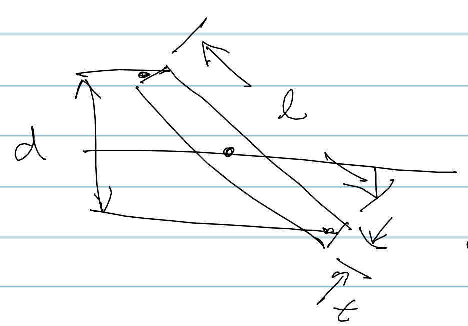
$i = \frac{1}{12} h t^3$

$= \frac{1}{12} a t^2$

$\frac{1}{12} a d^2$

$a = t \cdot l$

d = vert. extent



$i = \frac{1}{12} a d^2$

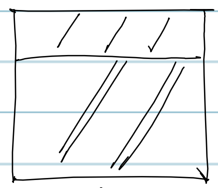
$a = t l$

h_{NA} $\quad I_{BASE} = \Sigma ay^2 + \Sigma i$

$$I_{NA} = I_{BASE} - A \cdot h_{NA}^2$$

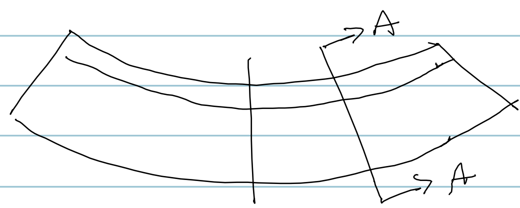
I of Composite Section

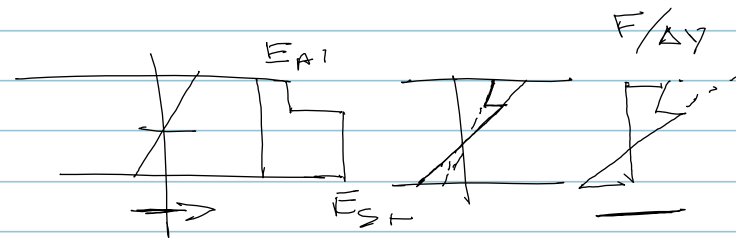
2 or more Materials.



Al $E \simeq 70$ GPa

steel $E \simeq 200$ GPa





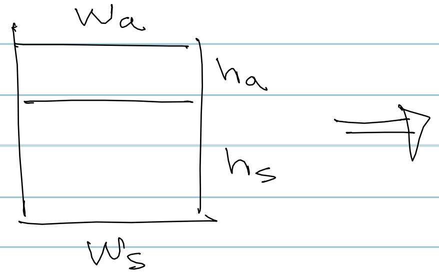
Strain

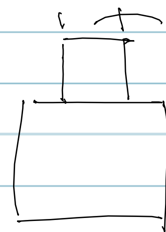
ε

Convert ⇒ Equiv. (All steel)

$\varepsilon = \frac{\sigma}{E}$

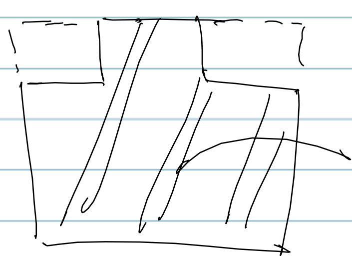
$\sigma = \varepsilon E$





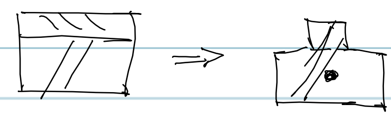
$w_{mod} = w_a \times E_{al} / E_{st.}$

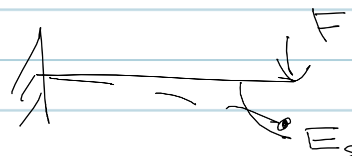
$W_{conv.} = W_{orig} \times \frac{E_2}{E_1}$



I_{eq}

∘ I_{eq}

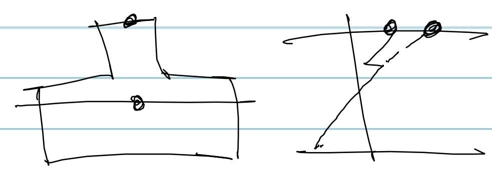




$$\delta_{end} = \frac{F L^3}{3 E_{st} I_{eq}}$$ ✓

$$\sigma_{steel} = \frac{M y_{st}}{I_{eq}}$$

$$\sigma_{al} \neq \frac{M y_{al}}{I_{eq}}$$



$$\sigma_{al} = \frac{M y_{al}}{I_{eq}} \times \frac{E_{al}}{E_{st}}$$ ↓

I_{eq} → stress
I_{eq} → ε ✓

$I_{eq} \to \delta$ one