Mi-2.05/...

ENGINEERING SECTION AREAS.

← Areas in m^2

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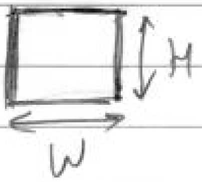
Most materials in Engineering are supplied in what is known as 'bar-stock' or 'Standard Stock Sections Sizes'. Here are a few, but are not limited to...

BAR ROUND SOLID

$$A = \frac{\pi D^2}{4}$$

(NB: $D = 2 \times r$)
(if r = radius is given)

SQR SECTION

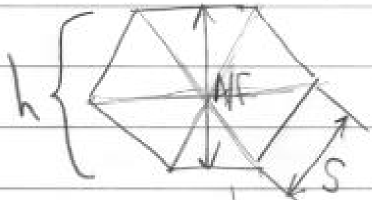


$$A = W \times H$$

HEX SECTION

where $A/f = h$

A/f = across flats.



$$A = \frac{6}{2} S \cdot \frac{h}{2}$$

TRIG RULES:—

$$\tan\theta = \frac{opp}{adj}$$

$$\therefore opp = adj \times \tan\theta$$

$$\left(\frac{S}{2}\right) = \left(\left(\frac{h}{2}\right)\tan 30^\circ\right)$$

$$\therefore S = 2\left(\frac{h}{2}\tan 30^\circ\right)$$

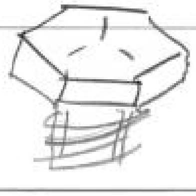
Thus

$$A = \left(\frac{6}{2}\right)\left(2\left(\frac{h}{2}\tan 30^\circ\right)\right)\cdot\left(\frac{h}{2}\right)$$

$$A = \left(\frac{6}{2}\right)\left(2\left(\frac{A/f}{2}\tan 30^\circ\right)\right)\cdot(A/f)$$

← Across flats Hex area by A/f dim only

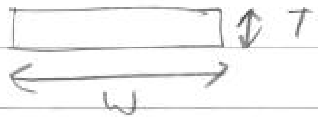
for a standard 6-sided Hex head!



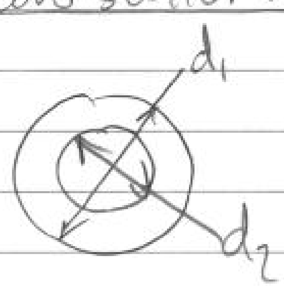
"BOLT"

PLATE SOLID & SHEET

$$A = W \times T$$

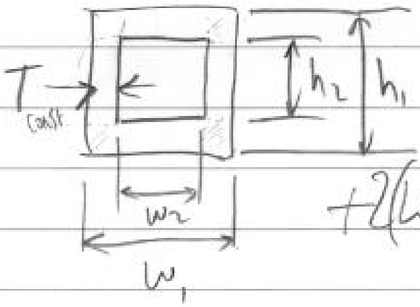


HOLLOW SECTION – TUBE



$$A = \left(\frac{\pi d_1^2}{4}\right) - \left(\frac{\pi d_2^2}{4}\right)$$

HOLLOW SECTION – SQR/BOX



$$A = (w_1 \times h_1) - (w_2 \times h_2)$$

$$\text{alt} = A = \cancel{2}\left(\frac{w_1 - w_2}{\cancel{2}} \times T\right) + \cancel{2}\left(\frac{h_1 - h_2}{\cancel{2}} \times T\right) + 2(w_2 \times T) + 2(h_2 \times T)$$

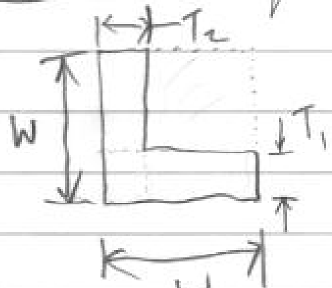
4 corners $\rightarrow$ $= (w_1 - w_2)T + (h_1 - h_2)T + 2(w_2 T) + 2(h_2 \times T)$

base + top ↗ left + right sides ↗

Assuming constant thickness.

$$\therefore A_T = (w_1 - w_2)\underset{\text{const}}{T} + (h_1 - h_2)\underset{\text{const}}{T} + 2(w_2 \underset{\text{const}}{T}) + 2(h_2 \underset{\text{const}}{T})$$

L section Equal angle



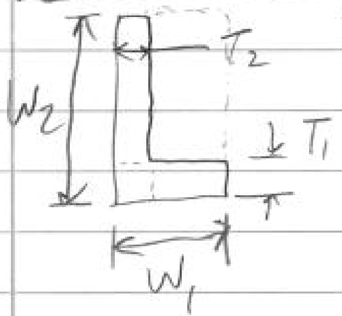
$$A = (W \times T_1) + (W \times T_2) - (T_2 \times T_1)$$

$$\text{alt: } A = (W \times W) - \left((W - T_1) \times (W - T_2)\right)$$

$$= W^2 - \left((W - T_1) \times (W - T_2)\right)$$

Assuming constant thickness $T_1 = T_2$; $A = (W \cdot T) + (W \cdot T) - (T^2)$

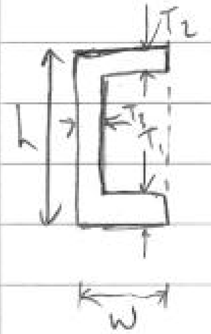
L-section Unequal Angle.



$$A = (W_1 \cdot T_1) + (W_2 \times T_2) - (T_2 \times T_1)$$

$$\text{alt} = A = (W_1 \times W_2) - ((W_1 - T_2) \times (W_2 - T_1))$$

C-section channel

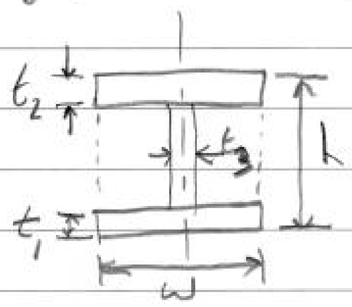


$$A = (h \times w) - ((w - T) \times (h - 2T))$$

$$\text{alt} = A = (h \times w) - ((w - T_3) \times (h - T_1 - T_2))$$

I-section (beam) channel

Simplified sections:-



Even / Equal 'w'

a) where $t_1 = t_2 = T$

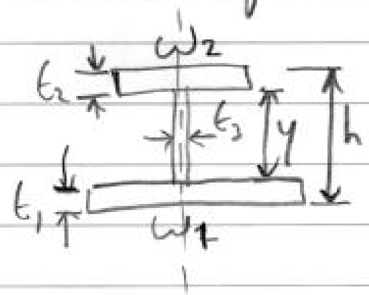
$$A = 2(Tw) + ((h - 2T) \times t_3)$$

b) where $t_2 \neq t_1$

$$A = t_1 w + t_2 w + ((h - t_2 - t_1) t_3)$$

Odd & Unequal: a) where t_1, t_2 & t_3 are different.
including 'w'

$$A = (t_1 w_1) + (t_2 w_2) + ((h - t_1 - t_2) t_3)$$



b) If dimension Y is given and not h

$$A = (t_1 w_1) + (t_2 w_2) + (t_3 Y)$$

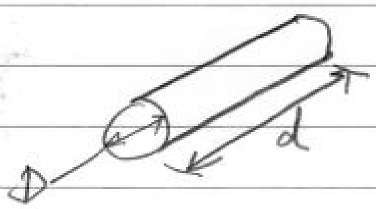
Volumes in m^3

SECTION VOLUMES.

The beauty in what we have described mathematically earlier, is that we can add a third dimension; depth, to the sectional shapes to calculate their volume:-

$$V = A \times d \qquad \text{(general formula)}$$

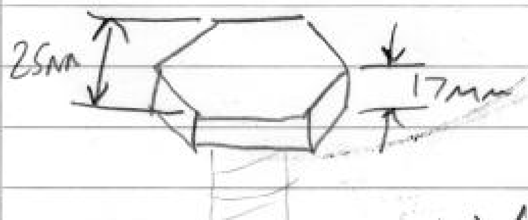
ie:- for a round cylindrical bar:-



we know $A = \frac{\pi D^2}{4}$

$$\therefore V = \frac{\pi D^2}{4} \times d \quad [m^3]$$

Example:- A Hex head bolt has width between flats of 25mm, calculate the volume of the bolt head if its depth is 17mm:-



$$V = A \times d$$

$$\therefore A = \left(\frac{6}{2}\right)\left(2\left(\frac{A/f}{2}\tan 30^\circ\right)\right)\cdot(A/f)$$

$$\therefore V = \left(\left(\frac{6}{2}\right)\left(2\left(\frac{Af}{2}\tan 30^\circ\right)\right)\cdot Af\right) \times d$$

(1000mm = 1m)

where $Af = 25mm$, $d = 17mm$.

25mm = 0.025m , 17mm = 0.017mm

$$[m^3]\ V = \left(\left(\frac{6}{2}\left(2\left(\frac{0.025}{2}\tan 30^\circ\right)\right)\cdot(0.025)\right) \times 0.017$$

$$= ((0.04330)\cdot(0.025)) \times 0.017$$

$$= 0.00108\,25 \times 0.017$$

$$= \underline{\underline{0.000018\ m^3}} = \underline{\underline{18.403\ \mu m^3}}$$

(micrometers cubed)

EX2 A special Hex-Head bolt has the following dimensions.

Calculate the bolts volume. what does it weigh if its material is of a density 8000 kg/m^3?

MASS = DENSITY X VOLUME

$M = \rho \times V$

Volume of head $\Rightarrow$ $A = \left(\frac{6}{2}\left(2\left(\frac{Af}{2}\tan 30°\right)\right) \cdot (Af)\right)$

$\therefore V = \left(\left(\frac{6}{2}\left(2\left(\frac{Af}{2}\tan 30°\right)\right) \cdot (Af)\right) \times L_1$

$= \left(\left(\frac{6}{2}\left(2\left(\frac{0.033}{2}\tan 30\right)\right) \cdot 0.033\right) \times 0.016$

$= 1.8862 \times 10^{-3} \times 0.016$

$\therefore V_1 = 30.179 \times 10^{-6}\ m^3$

Volume of threaded section $\Rightarrow$ $A = \frac{\pi D^2}{4}$

$\therefore V = \frac{\pi D^2}{4} \times L_2$

$= \frac{\pi\, 0.0127^2}{4} \times 0.028$

$\therefore V_2 = 3.5469 \times 10^{-6}\ m^3$

Total Volume $\Rightarrow$ $\Sigma V = V_1 + V_2$

$= 30.179 \times 10^{-6} + 3.5469 \times 10^{-6}$

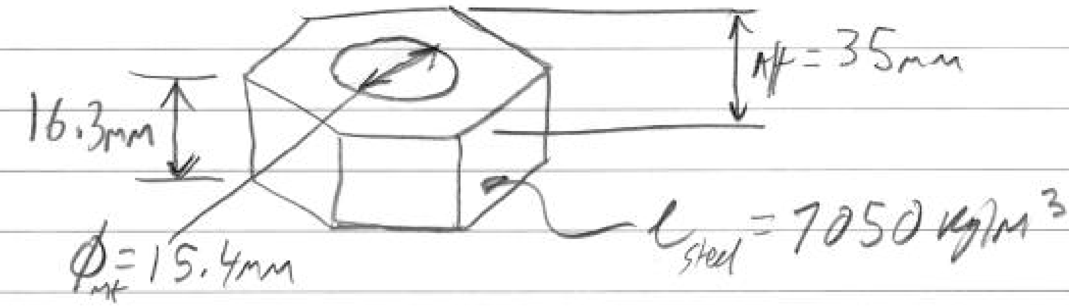
$= 33.7259 \times 10^{-6}\ m^3$

$= 33.7\ mm^3$

$\therefore M = \rho \times V = 8000 \times 33.7 \times 10^{-6}$

$= 0.2696$ Kg each

EX3 a) Calculate the approximate volume and weight of the nut dimensioned below:-



$$M = \rho \times V$$

where $V = V_{nut\ blank} - V_{hole}$

$$\therefore V = \left(\left(\tfrac{6}{2}\right)\left(2\left(\tfrac{Af}{2}\tan 30\right)\right)\cdot Af\right)\times h\right) - \left(\frac{\pi D^2}{4}\times h\right)$$

$$= \left(\left(\tfrac{6}{2}\right)\left(2\left(\tfrac{0.035}{2}\tan 30^\circ\right)\right)\cdot 0.035\right)\times 0.0163\right) - \left(\frac{\pi\, 0.0154^2}{4}\times 0.0163\right)$$

$$= \left(34.585\times 10^{-6}\right) - \left(3.0361\times 10^{-6}\right)$$

$$= \underline{31.5489\times 10^{-6}\,m^3} = \underline{31.55\,\mu m^3}$$ ✓

$$M = 7050 \times 31.55\times 10^{-6}$$
$$= \underline{0.2224\,Kg}$$ each nut.

b) If a batch of 220 nuts were purchased what would be the total weight of the batch?

$$M_T = XM = (220)\,0.2224$$
$$= \underline{48.93\,Kg}$$

"TITANIC NUTS!"