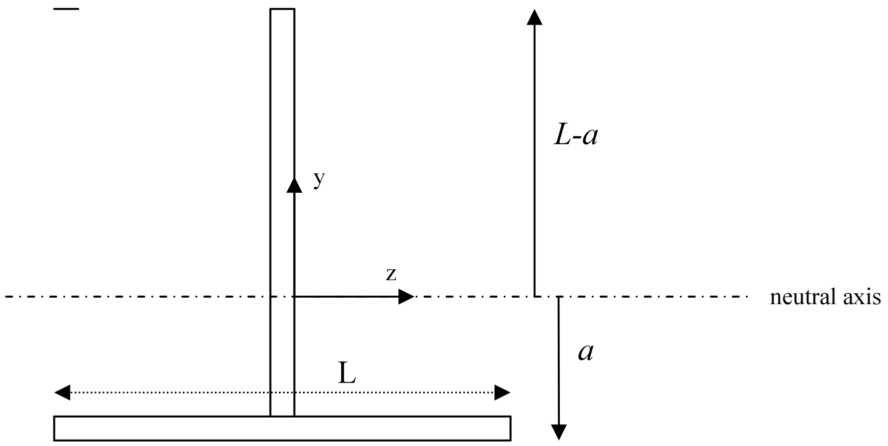
Homework Tutorial Session 1

Mentor Guide Question

1.4 Define the second moment of area ("moment of inertia") and derive its value in simple cases. *The latter part is covered by the questions below*.

Numerical Questions

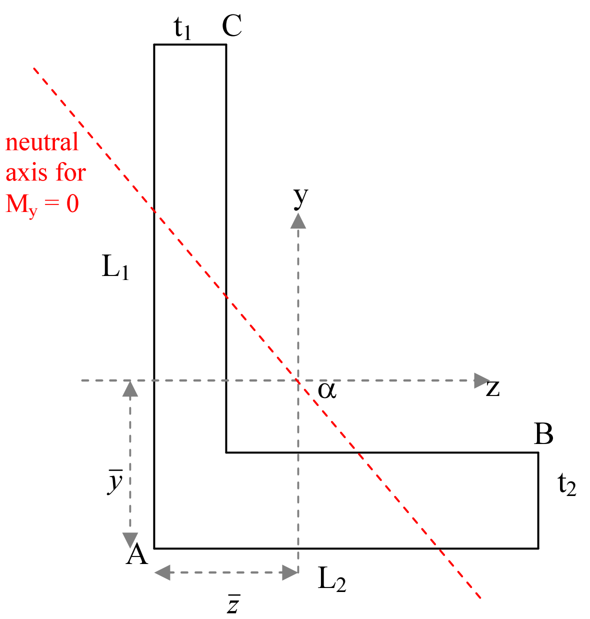
1) Find the moment of inertia (second moment of area, I) of the T-section defined in the session #1 notes, i.e.,



Work in the approximation $t << L$ for simplicity (for which $a = L/4$).

2) Prove that the moment of inertia (second moment of area, I) of a pipe with inner and outer diameters D_i and D_o is $I = \frac{\pi}{64}\left(D_o^4 - D_i^4\right)$.

3) For the L-section…



…the position of the centroid and the three second moments of area are,

$$\bar{y} = \frac{t_1 L_1^2 + (L_2 - t_1)t_2^2}{2(t_1 L_1 + t_2 L_2 - t_1 t_2)} \qquad \bar{z} = \frac{t_2 L_2^2 + (L_1 - t_2)t_1^2}{2(t_1 L_1 + t_2 L_2 - t_1 t_2)}$$

$$I_z = \frac{t_1}{3}\left[(L_1 - \bar{y})^3 + \bar{y}^3\right] + \frac{L_2 - t_1}{3}\left[\bar{y}^3 - (\bar{y} - t_2)^3\right]$$

$$I_y = \frac{t_2}{3}\left[(L_2 - \bar{z})^3 + \bar{z}^3\right] + \frac{L_1 - t_2}{3}\left[\bar{z}^3 - (\bar{z} - t_1)^3\right]$$

$$I_{yz} = -\frac{1}{4}\left\{\left[(L_1 - \bar{y})^2 - \bar{y}^2\right]\left[\bar{z}^2 - (\bar{z} - t_1)^2\right] + \left[(L_2 - \bar{z})^2 - (\bar{z} - t_1)^2\right]\left[\bar{y}^2 - (\bar{y} - t_2)^2\right]\right\}$$

If the dimensions of the L-section are $L_1 = 100$mm, $L_2 = 60$mm and $t_1 = t_2 = 10$mm use the formulae to find the second moments of area and hence find the orientation of the neutral axis (angle $-\alpha$ in the Figure) for the case of a bending moment applied about the z-axis. If the magnitude of the bending moment is 1 kNm and it is applied in the positive (right-hand rule) sense, find the stresses at points A, B and C. (Careful with the units – do note that 1 kNm = 10^6 Nmm).

4) **<u>Optional Question</u>**: Derive the formulae in Qu.3.

Plant Example

5) The superheater tailpipes at HPB & HNB convey the steam from the main boilers to the s/h penetrations, where it egresses the reactor. Where the tailpipes are welded to the tubeplate at the penetration there is a tapered feature called a pintle. At the thin end of the pintle the dimensions are: OD 66.7mm, ID 53.0mm. At the thick end of the pintle the ID is the same but the OD is 103mm. The pintle is subject to a bending moment of 4.4 kNm.

Evaluate the bending stress at both the thin end and the thick end of the pintle.

Given that the lower bound yield strength is 125 MPa, what would you conclude?