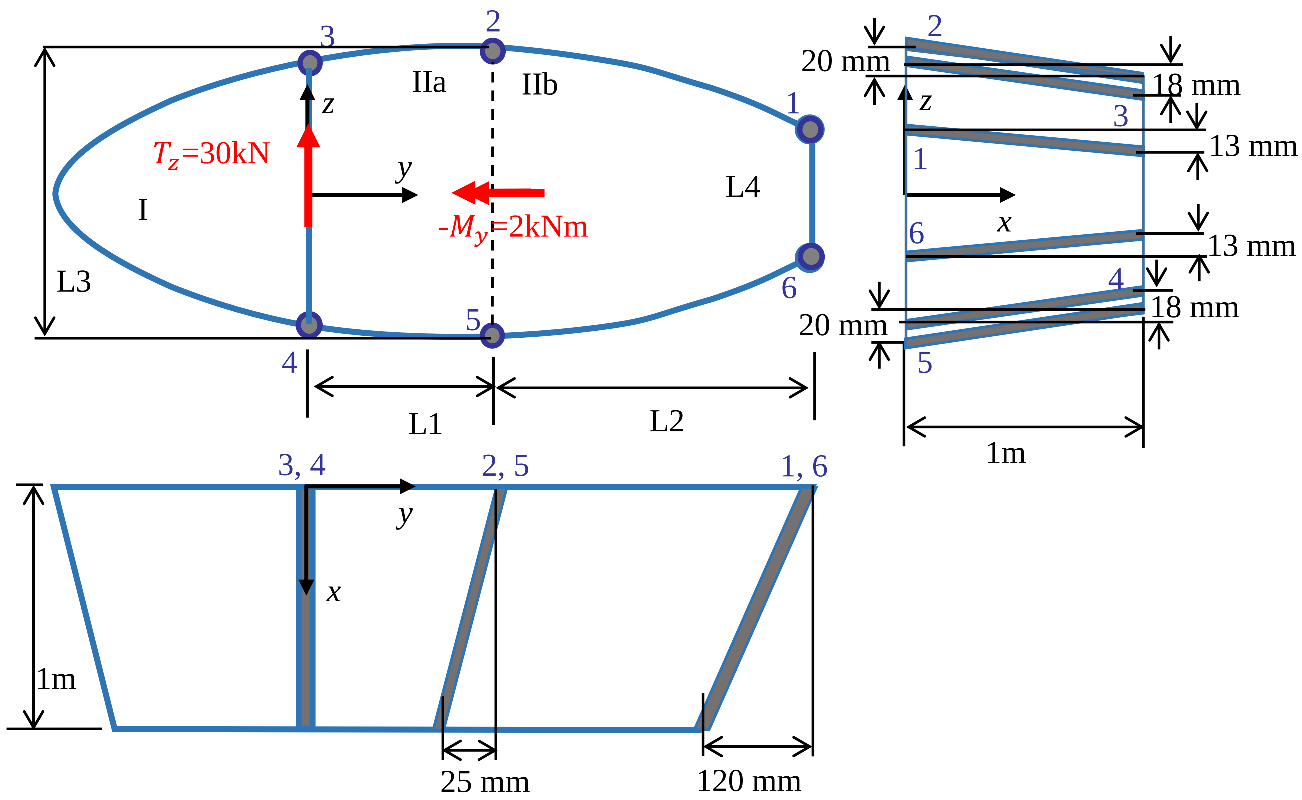
Aeronautical Structures (MECA0028-1)

June 2022

Question n° 1



Wall	Length (mm)	Thickness (mm)	Shear modulus (GPa)
12, 56	1045	0.5	22
23, 45	290	0.5	22
34(	1045	0.5	22
34I	396	1.5	71
61	275	0.5	22

Boom	Section (mm^2)
1, 6	1 000
2, 5	1 300
3, 4	1 200

Cell	Area (mm^2)
I	139 000
IIa	127 000
IIb	381 000

Distance	Length (mm)
L1	275
L2	990
L3	440

The tapered wing cross-section depicted here above has two closed cells "I" and "II" (without wall between booms 2 and 5). The section is already idealized with its properties reported in the four Tables here above. The area of the cell II is given in two parts: the part left to the virtual line 25 and the part right to the virtual line 25.

We consider the following assumptions

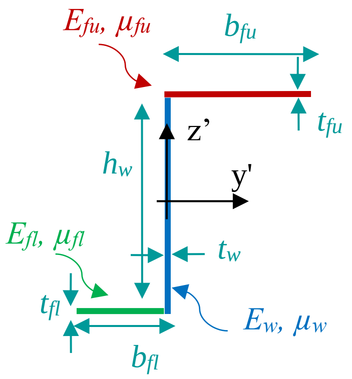
- The booms carry the direct stress (due to bending) only;
- The skin panels sustain the shear stress only;

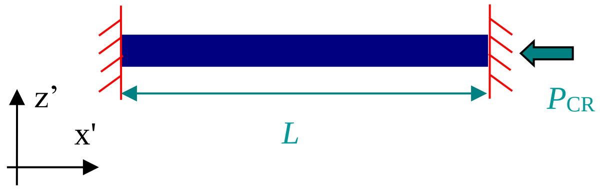
- The cross-section has a single symmetry;
- Twist and shear centres are assumed to coincide.

You are requested to compute

1. The location of the bending inertia centre;
2. The second moments of area Iyy, Iyz and Izz;
3. The direct stress in each boom;
4. The shear flow in each wall;
5. The cross-section twist rate;
6. The shear stress in each wall.

Question n° 2





Upper Flange		Web		Lower flange	
Thickness t_{fu} [mm]	2.5	Thickness t_w [mm]	3.	Thickness t_{fl} [mm]	2.
Width b_{fu} [mm]	40.	Height h_w [mm]	80.	Width b_{fl} [mm]	20.
Young's modulus E_{fu} [GPa]	24.	Young's modulus E_w [GPa]	72.	Young's modulus E_{fl} [GPa]	48.
Shear modulus μ_{fu} [GPa]	8.	Shear modulus μ_w [GPa]	25.	Shear modulus μ_{fl} [GPa]	16.

An S-stringer cross section is illustrated here above. The flanges and web are made of 3 different laminates. The geometrical and material properties are reported in the Table here above.

Considering that **the walls thickness can be assumed small compared to the other dimensions**, you have to answer to the following questions:

1. Where is the location of the inertia centre C governing the bending behaviour? Be careful that **different materials are involved in the beam** cross-section.
2. In the referential linked to the inertia centre C, what are the values of the modified second moments of area EI_{yy}, EI_{zz}, and EI_{yz}, governing the bending behaviour?
3. Where is the location of the shear centre S?
4. What are the principal axes of inertia?
5. What are the modified second moments of area EI_1, EI_2 expressed in the principal axes?
6. Assuming a 2 m-long beam, which is clamped at both extremities, what is the Euler critical buckling load when torsion is not allowed?

Tips:

1) Thin walls approximation can be used ;
2) For point 3, starting from the complete formulas for different Young moduli, pay attention to the position of the centre of inertia and the loss of symmetry of the section ; consider successively the position according to y and z (choose smartly the point for the equilibrium of moments!);
3) Direction α of principal axis follows from $\tan(2\alpha) = \frac{2EI_{yz}}{EI_{yy}-EI_{zz}}$;
4) Equation $\tan(x) = y$ has two solutions x between $-\pi$ et π ;
5) The main modified moments of inertia according to the main axes are $EI_1 = EI_{yz}\tan(\alpha_1) + EI_{yy}$ and $EI_2 = EI_{yz}\tan(\alpha_2) + EI_{yy}$ or $EI_1 = EI_{yz}/\tan(\alpha_1) + EI_{zz}$ and $EI_2 = EI_{yz}/\tan(\alpha_2) + EI_{zz}$