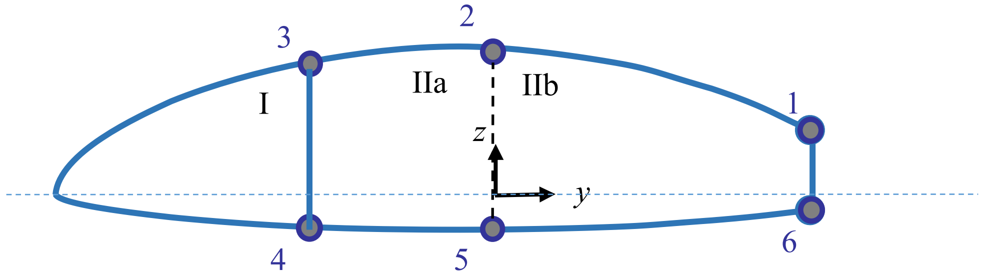
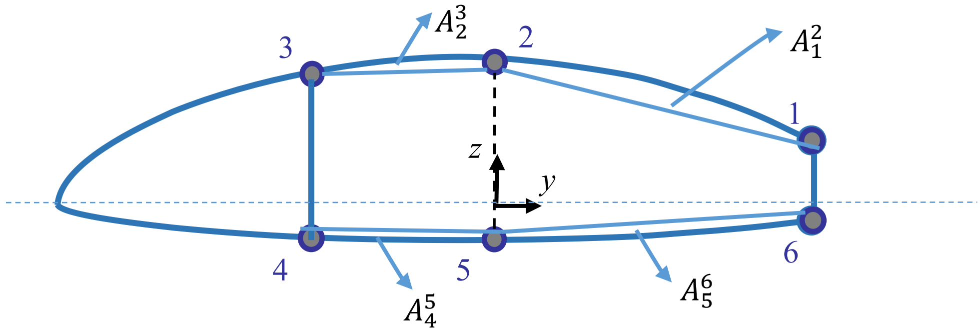
Aeronautical Structures (MECA0028-1)

June 2025

Question n° 1





Boom	y (mm)	z (mm)	Section (mm^2)
1	950	100	1 000
2	0	300	1 000
3	-250	250	1 000
4	-250	-125	1 000
5	0	-125	1 000
6	950	-25	1 000

Wall	Length (mm)	Thickness (mm)	Shear modulus (GPa)
12	1100	0.5	22
23	300	0.5	22
34(	950	0.5	22
34I	375	1.5	22
45	275	0.5	22
56	1000	0.5	22
61	125	0.5	45

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

Cell	Area (mm^2)
I	100 000
IIa	120 000
IIb	300 000

Arc	Area (mm^2)
A_1^2	25 750
A_5^6	13 000
A_2^3	15 000
A_4^5	5 000

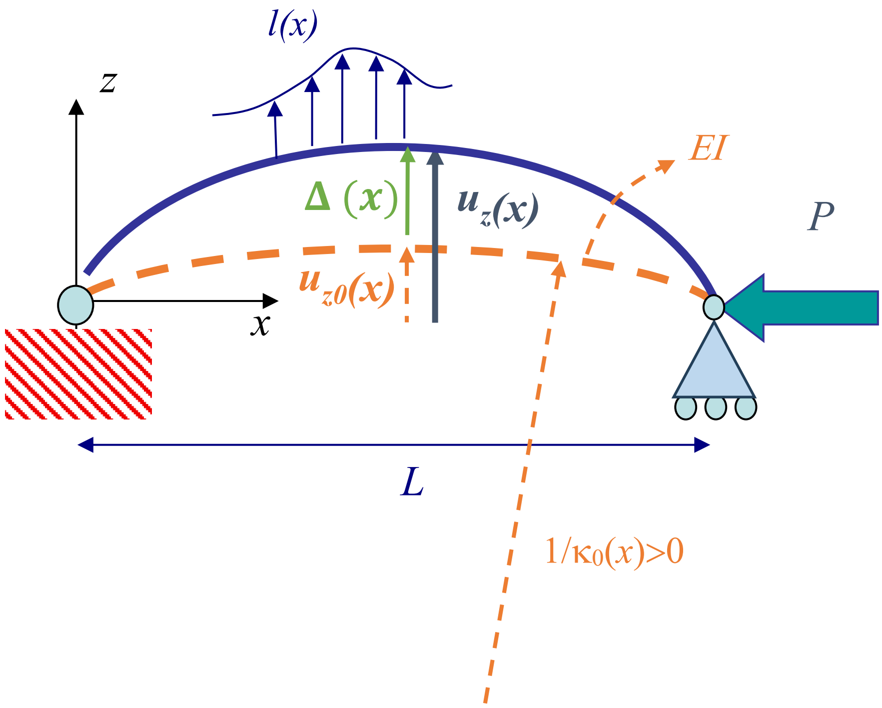
The wing cross-section depicted here above has two closed cells “I” and “II” (**without wall between booms 2 and 5**). The section is already idealized with its properties reported in the five Tables here above. The area of the cell II is given in two parts: the part left to the virtual line 25 and the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

- All the booms have the same Young’s modulus;
- The booms carry the direct stress (due to bending) only;
- The skin panels sustain the shear stress only;
- The taper effect can be neglected;
- Twist and shear centres are assumed to coincide.

You are requested to compute

1. The location of the shear centre of the wing. When computing the moment equations, you are advised to take as origin either the origin of the depicted coordinate system or Boom 5.
2. The twist rate for a load T_y= 12 kN, T_z = 27kN passing through this shear centre.

Question n° 2



A stringer of uniform Young's modulus E and inertia I has an initial deformed shape characterized by the curvature $\kappa_0(x)$, see orange dashed line here above. The stringer is simply supported at each edge and subjected to a compressive load $P > 0$ —following the figure— and a distributed load per unit length $l(x)$. The stringer initial location is defined by $u_{z0}(x)$ and the deformed stringer location by $u_z(x) = u_{z0}(x) + \Delta(x)$.

You are requested to study the effect of the initial curvature and of the compressive load on the stringer deflection $\Delta(x)$. To do so you are requested to follow the following steps

1) Using a second-order theory, express the partial differential equation governing the stringer deflection $\Delta(x)$.
2) Assuming a constant curvature $\kappa_0(x) = \kappa_0$, a constant load distribution $l(x) = l_0$, and a strictly compressive load $P > 0$, solve this equation in terms of the stringer deflection $\Delta(x)$.
3) Assuming a stringer length $L = 2$ m, a Young's modulus $E = 71\ GPa$, an inertia $I =$ 20 800 mm^4, a Poisson's ratio of 0.3, and a distributed load $l_0 = 1\,\frac{\text{kN}}{\text{m}}$, evaluate the mid-length stringer deflection $\Delta\left(\frac{L}{2}\right)$ successively for the couples ($\kappa_0 = 0\,, P = 1$ kN), $\left(\kappa_0 = -0.1\,\frac{1}{\text{m}}\,, P = 1\text{ kN}\right)$, $\left(\kappa_0 = -0.1\,\frac{1}{\text{m}}\,, P = 1\text{ N}\right)$
4) Compare these results with the 1st order analytical solution of a straight beam under uniform loading $\Delta^{1st}\left(\frac{L}{2}\right) = \frac{5\,L^4\,l_0}{384\,EI}$ and explain/justify the differences.