Assignment 2
3D bars: Hang glider

The hang glider depicted in Figure 1 descends at constant velocity. Its structure is composed of bars of two different materials, with their properties given in Table 1. Consider the following loading conditions:

a) A mass $M = 150$ kg is attached to the lower bar, and its weight (W_M) is distributed equally among nodes 1 and 2. Note: consider $g = 9.81$ m/s^2.
b) The mass of the bars is NOT negligible, and their weight is distributed equally among each bar's nodes.
c) The total aerodynamic lift L and drag D are distributed uniformly among the upper surface nodes.
d) The pilot applies a force T, distributed equally among nodes 1 and 2, to prevent the rotation of the structure around the y-axis.

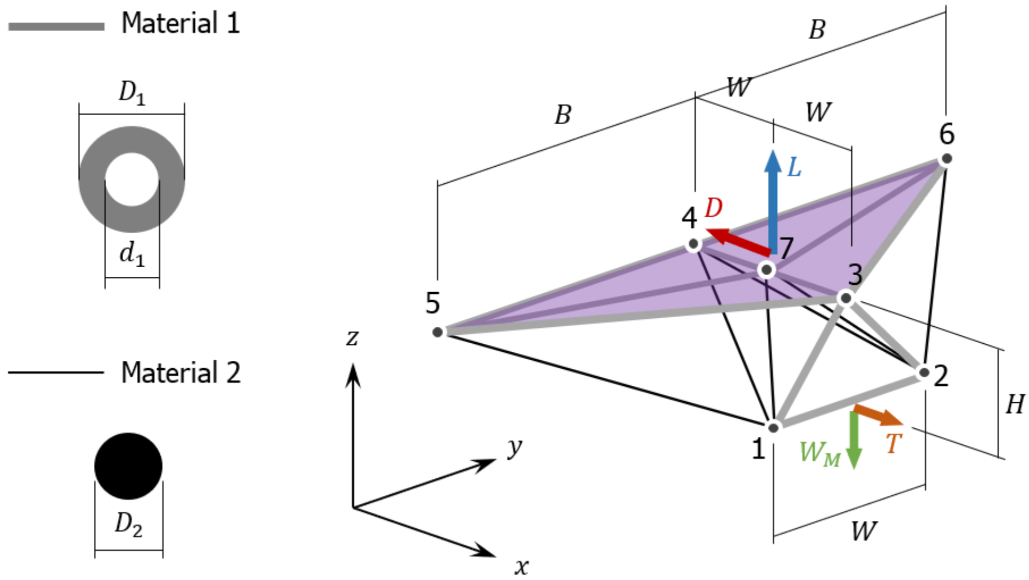

Figure 1. Hang glider structure and external loads. Consider $H = 0.9$ m, $W = 0.85$ m and $B = 3.2$ m. Note: although the weight of the bars is not depicted, it must be taken into account.

Table 1. Material properties

	Young's Modulus (MPa)	Density (kg/m^3)	Section properties	
Material 1	75000	3350	$D_1 = 18.0$ mm	$d_1 = 7.5$ mm
Material 2	147000	950	$D_2 = 3.0$ mm	

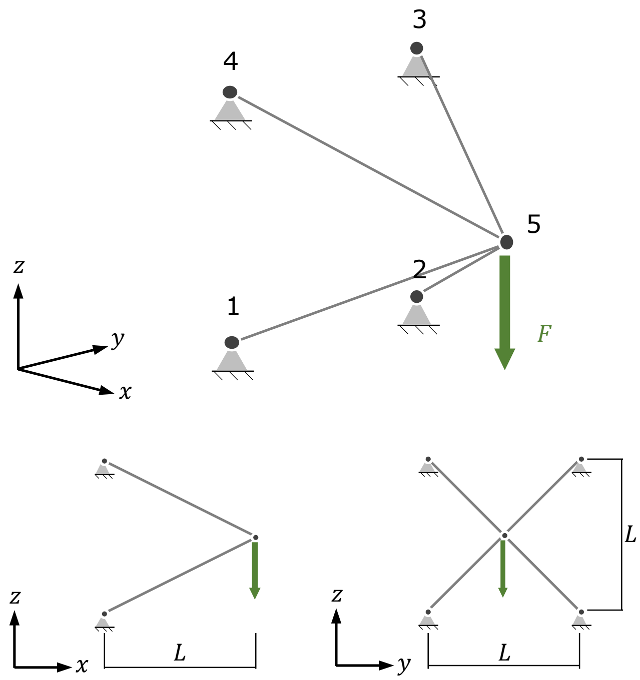

Figure 2. Test problem for 3D bars code (choose your own values for the parameters).

A) Following the "ALG_3DBAR" guide, modify the MATLAB® code for Assignment 1 and adapt it to the 3D case. Use the structural assembly in Figure 2 to validate the code, by comparing numerical and analytical results.

B) Compute the stress state of each bar and cable in the hang glider and discuss the following questions:

1. Which degrees of freedom have been prescribed in order to solve the system of equations and find the nodal displacements? Provide the values of the reactions obtained in the prescribed degrees of freedom and discuss their physical meaning?
2. Use the following formula to evaluate the critical stress for buckling on each bar:
$$\sigma_{cr} = \frac{\pi^2 EI}{A\ell^2}$$
where E is the Young Modulus, I the section inertia, A the section area and ℓ the bar's length. Evaluate whether there is risk of buckling on the structure and provide a feasible solution to prevent it, if necessary.
3. A sudden gust produces a 10% increase of the aerodynamic loads acting on the structure, as a consequence:
   - The pilot is forced to sustain an extra force T' in order to prevent the glider from rotating about the centre of mass of the system.
   - An inertial load appears, due to the non-equilibrium in the x and z directions (non-null rigid body acceleration components).

   In such conditions, compute the new stress state of the structure.

The assignment can be done in groups of maximum 2 people. Only one of the members must submit a compressed ZIP file to Atenea containing the following:

- All the MATLAB® script files.
- A report with the following information:
  - Names of the group members.
  - For part A:
    - Derivation of the analytical results.
    - Table comparing analytical and numerical results (stress of each bar).
  - For part B:
    - Derivation of the equilibrium equations and procedure to compute L, D and T for conditions B.1 and B.3 (for B.3 provide the value of the acceleration a_x and a_z).
    - Discussion for question B.1 about the prescribed degrees of freedom.
    - Table with stress of each bar/cable for conditions B.1 and B.3.
    - Plot of the deformed structure (use the "**plotBarStress3D**" function) for conditions B.1 and B.3.
    - Table with critical stress of each bar and risk of buckling assessment for conditions B.1 and B.3.