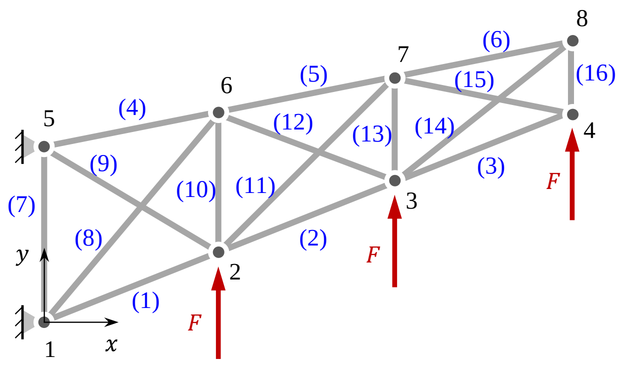
Assignment 1 – Bars

Consider the articulated bars structure shown in Figure 1. The position of nodes 1 and 5 is fixed and a force F acts in the indicated nodes and direction. All bars are made of the same material, with a Young's modulus, section area (squared) and density given below.

Force: $F = 750$ N
Young's modulus: $E = 70000$ MPa
Section area: $A = 72$ mm^2
Density: $\rho = 2200$ kg m^{-3}



Node	x (m)	y (m)
1	0	0
2	0.5	0.2
3	1	0.4
4	1.5	0.6
5	0	0.5
6	0.5	0.6
7	1	0.7
8	1.5	0.8

Figure 1. Sketch of the structure

A- The purpose is to determine stress state of each bar, whether it is traction (+) or compression (–). To do so, run the MATLAB® file **`main_01`** after completing the following steps:

1. Find a relation f between the global degrees of freedom (DOFs) numbering with the global nodal numbering of the structure. Consider that each node may have n_i degrees of freedom associated:

$$I = f(n_i, a, i)$$

   where I is the global number assigned to the degree of freedom i of node a.

2. Create a function in MATLAB® to generate the degrees of freedom connectivity table. Use the script file **`connectDOFs`** for help.

3. Create a function in MATLAB® to generate the stiffness matrices for bar elements. Use the script file **`computeKelBar`** for help.

4. Create a function in MATLAB® to perform the global stiffness matrix assembly. Use the script file **`assemblyKG`** for help.

5. Create a function in MATLAB® to generate the global force vector. Use the script file **`computeF`** for help.

6. Create a function in MATLAB® to obtain the vectors of free and prescribed DOFs as well as the prescribed displacement vector. Use the script file **`applyCond`** for help.

7. Create a function in MATLAB® to solve the system of equations and obtain the nodal displacements and reactions in the prescribed DOFs. Use the script file **`solveSys`** for help.

8. Create a function in MATLAB® to compute the strains and stresses of each bar in the structure. Use the script file **`computeStrainStressBar`** for help.

B- Assume you have already acquired the total amount of material required to build the structure in Figure 1 (in terms of total bar longitude). Talking with the material supplier, you have managed to get the following offers:

- Buying extra material will have a cost of 320€/kg.
- You can sell the excess material at a price of 46€/kg.

Under the following restrictions:

- The loading and boundary conditions cannot be changed.
- The material properties (including the section area) of the bars cannot be modified.
- <u>All</u> the nodes must remain in the same position as in the structure in Figure 1 (Bars 1-6 and 16 cannot be removed).

Propose a redesign of the structure if the goal is:

1. Minimize cost/maximize benefits.
2. Minimize cost/maximize benefits guaranteeing a maximum stress at <u>traction</u> under 50 MPa.

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. Make sure that the code runs successfully when executing the script **`main_01`**.
- A report including:
  - Names of the group members
  - Table with the displacements of each node obtained numerically in part A.
  - Table with the stress for each bar obtained numerically in part A.
  - Values of the reactions at the fixed nodes obtained in part A.
  - Plot of the deformed structure with the stress of each bar in part A.
  - Plot of the deformed structure with the stress of each bar obtained with the redesigns proposed in part B, along with a proper justification.

Note 1: The report can be written in Catalan, Spanish or English and both technical and presentation aspects will be considered in the grading.