finite elements

homework assignment 2

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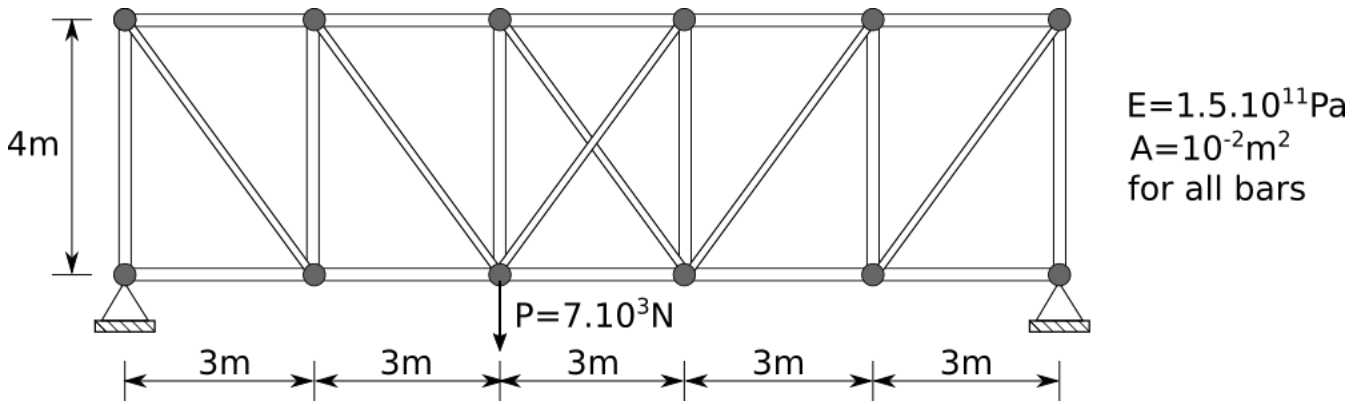
Using you MATLAB finite element code

a. Solve for the nodal displacements and stresses of the structure shown in the figure below.

b. Plot the deformed structure with MATLAB. For this purpose, add the mag $\times$ displacement to the nodal coordinates. The factor mag is to magnify the displacements so that they are visible.



Using the MATLAB finite element code, find the displacements and forces in the two truss structures given in the figure below. For truss structure (b), exploit the symmetry. For the two trusses, check the equilibrium at node 1. The Young's modulus $E = 10^{11}\,\mathrm{Pa}$, cross-sectional areas of all bars $10^{-2}\,\mathrm{m}^2$, forces $F = 10^3\,\mathrm{N}$, and $L = 2\,\mathrm{m}$.

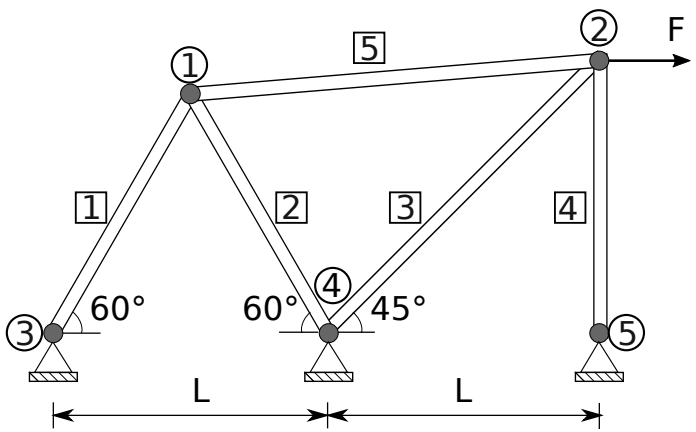


Figure: a

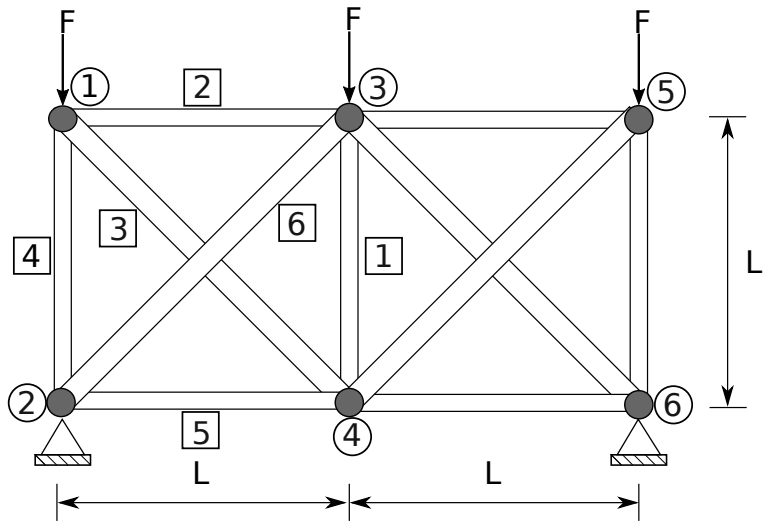
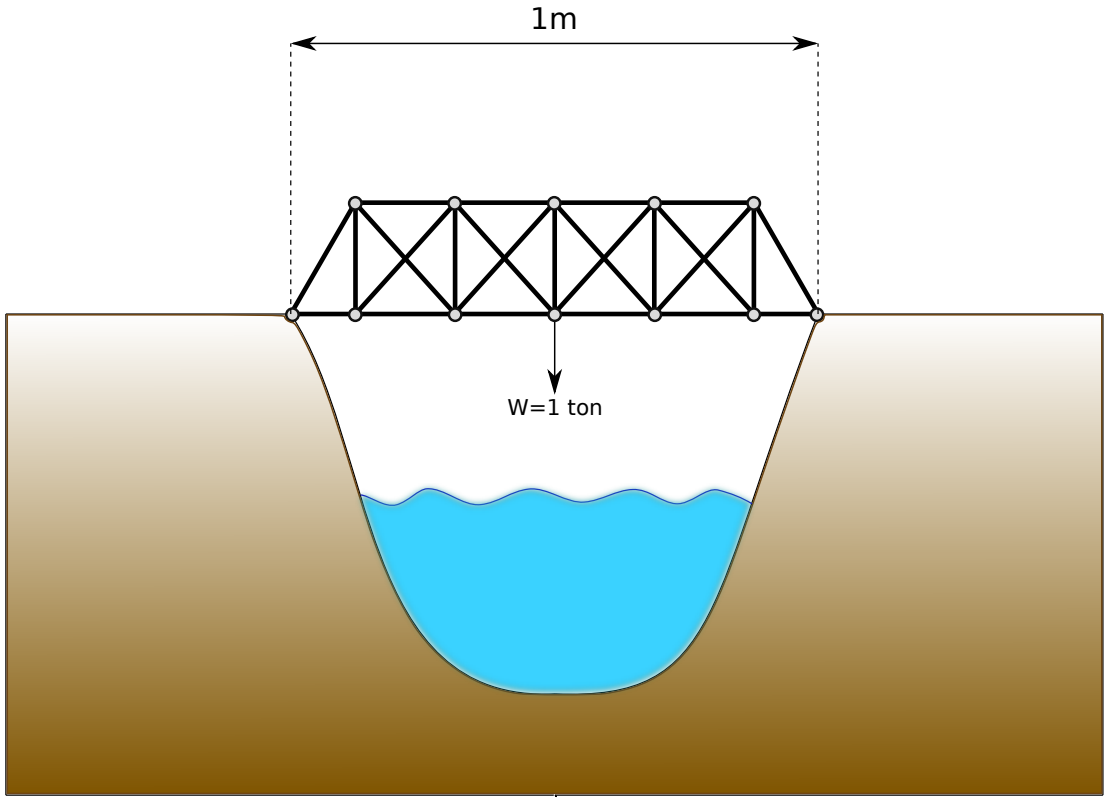


Figure: b

As shown in the figure below, the two sides of a river are connected through a bridge. The objective of this homework is to design a bridge such that it has the least weight and at the same time it results in the least deflection. The distance between the two sides of the river is $1\ \mathrm{m}$. A load of $1\ \mathrm{ton}$ is exerted in the middle of the bridge. The bridge consists of truss elements made from steel.



In your design, you must test different bridge topologies, element numbers, element connectivities etc. in order to find an optimum design. You can start with a simple design and check the deflection and the stress distribution. Then by removing the elements that are holding the least stress and adding elements at critical locations, you obtain a better design. One expects the "ideal" bridge to have identical stresses on all the elements. The final objective of your design is to obtain the least value of $(weight \times \delta)$ where $weight$ is the total weight of the structure and δ is the deflection at the point where the load is applied. This problem may or may not have a unique solution, therefore do not seek for a specific answer. Your reports must contain all of the structures you have tested as well as the reasoning about the improvements that you apply to your design in each iteration. For each case you have to show the stress distribution, the structure's weight, the deflection and the optimization criterion $(weight \times \delta)$.

Here are some design constraints you have to be careful about:

- The cross section of each truss element is circular with the radius of $1\ \mathrm{cm}$.
- The density of the steel is assumed to be $8000\ \frac{\mathrm{kg}}{\mathrm{m}^3}$ and its Young's modulus is $210\ \mathrm{GPa}$.
- All of the truss elements must have the same cross section area.
- The maximum allowable weight of the structure can not exceed $100\ \mathrm{kg}$.
- The design must be such that the load is applied on a node (not at element).